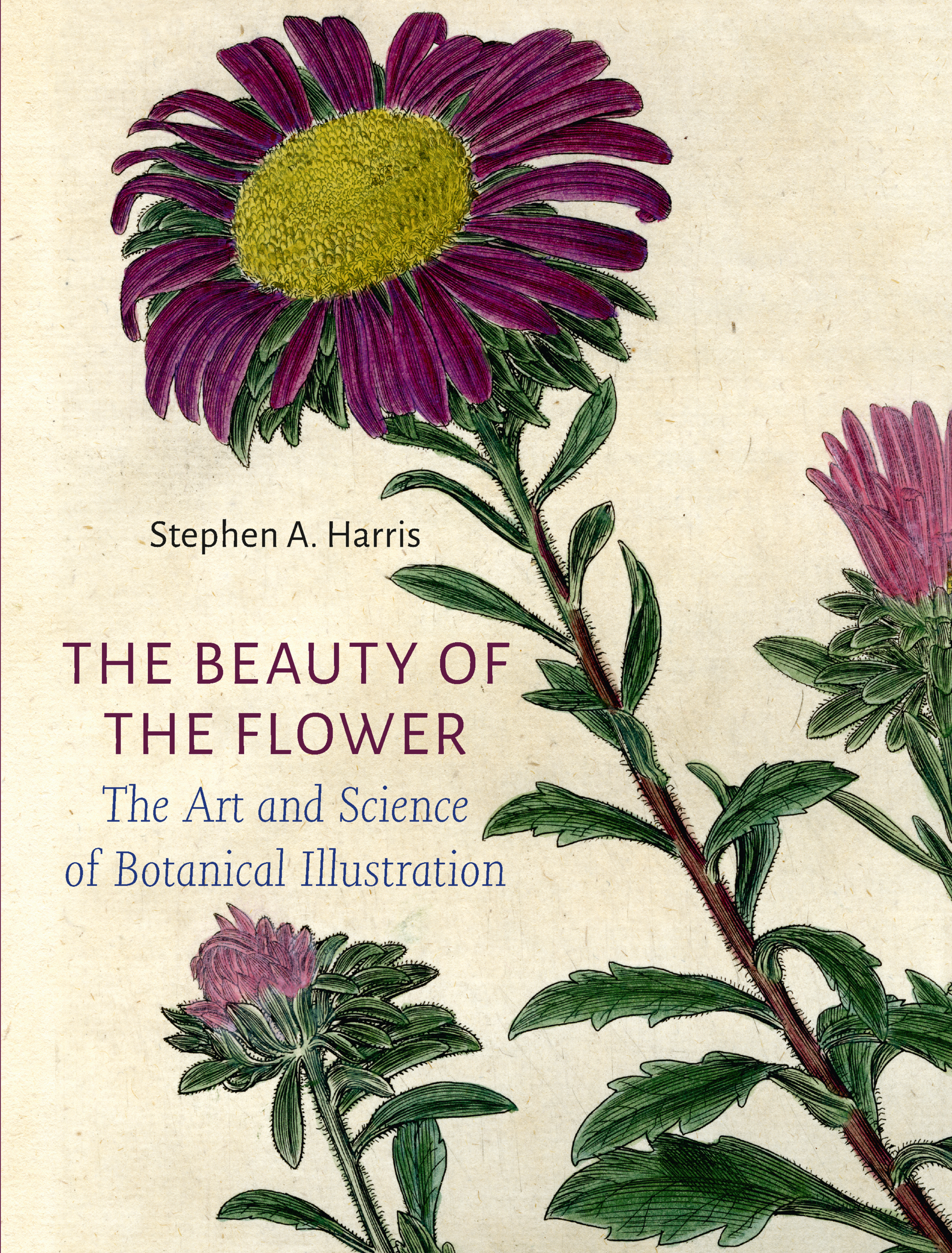

Stephen A. Harris

THE BEAUTY OF THE FLOWER

The Art and Science of Botanical Illustration

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REAKTION BOOKS

To Mum, Linda Harris (1945–2022), who in her unique way instilled in me a love of nature and encouraged me to see.

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Miss Saunders, Del. BÉLLIS PERÉNNIS. COMMON DAISY. ♃ T. Mathews Sc.

PREFACE

> That honest and courteous man *Iohn Van ufele*, who returning out of that part of America called Brasile, shewed mee in the yeare 1607, a booke, wherein he in liuely colours had exprest some plants and liuing creatures: for as he told me, when he purposed to trauell he learned to paint, that so he might expresse in colours, for his memorie and delight after he was returned home, such singularities as he should observe abroad.
>
> JOHN GERARD, *The Herball; or, General Historie of Plantes* (1633)[1]

Humans are a visual species. Consider how many digital images we now take every minute of every day across the planet to document our lives, our relationships and the world we inhabit as we try to create memories, validate perceptions and influence others. There is a belief that images cross cultures, prove worth and authenticity, and engage people in manners that words and written language alone cannot. Moreover, the adage 'seeing is believing' implies that images have a special association with truth; that they do not lie. However, images are as prone to manipulation, misrepresentation and misinterpretation as are written and spoken words, and therefore as open to examination, interpretation and criticism. Perhaps more so – especially when beautiful images are used to influence our ideas, social interactions and recollections. Consider how corporations, governments and advertisers use photographs to manipulate our interpretations of, and feelings about, people and events to sell or promote all manner of products and views. Consequently, for images to be rigorous scientific evidence, they must be calmly contextualized before being interpreted with curious scepticism.

Hand-coloured metal engraving of the common daisy by C. Mathews, based on an original illustration by Miss Saunders, an artist who contributed her work to William Baxter's six-volume *British Phaenogamous Botany* (1834–43). The illustration shows details of the daisy's habit and flowers, giving the viewer a different perspective on one of the commonest British wildflowers.

Tens of thousands of years ago we began using images to document the natural world, including animals that feed us, plants that heal us and things that have decorative, spiritual and symbolic significance. Botanical illustration, which emerged in numerous cultures across the globe, is the discipline of creating technically accurate depictions of plants. In European natural sciences, the rise of botanical illustration is associated with the Renaissance, after which it flourished as eighteenth-century Europeans began to girdle and dominate the world. However, by the end of the nineteenth century botanical illustration was in decline. Artistic establishments dismissed it as mere technical drawing, while scientific priorities changed and scientists discovered alternative means to illustrate and record their discoveries.

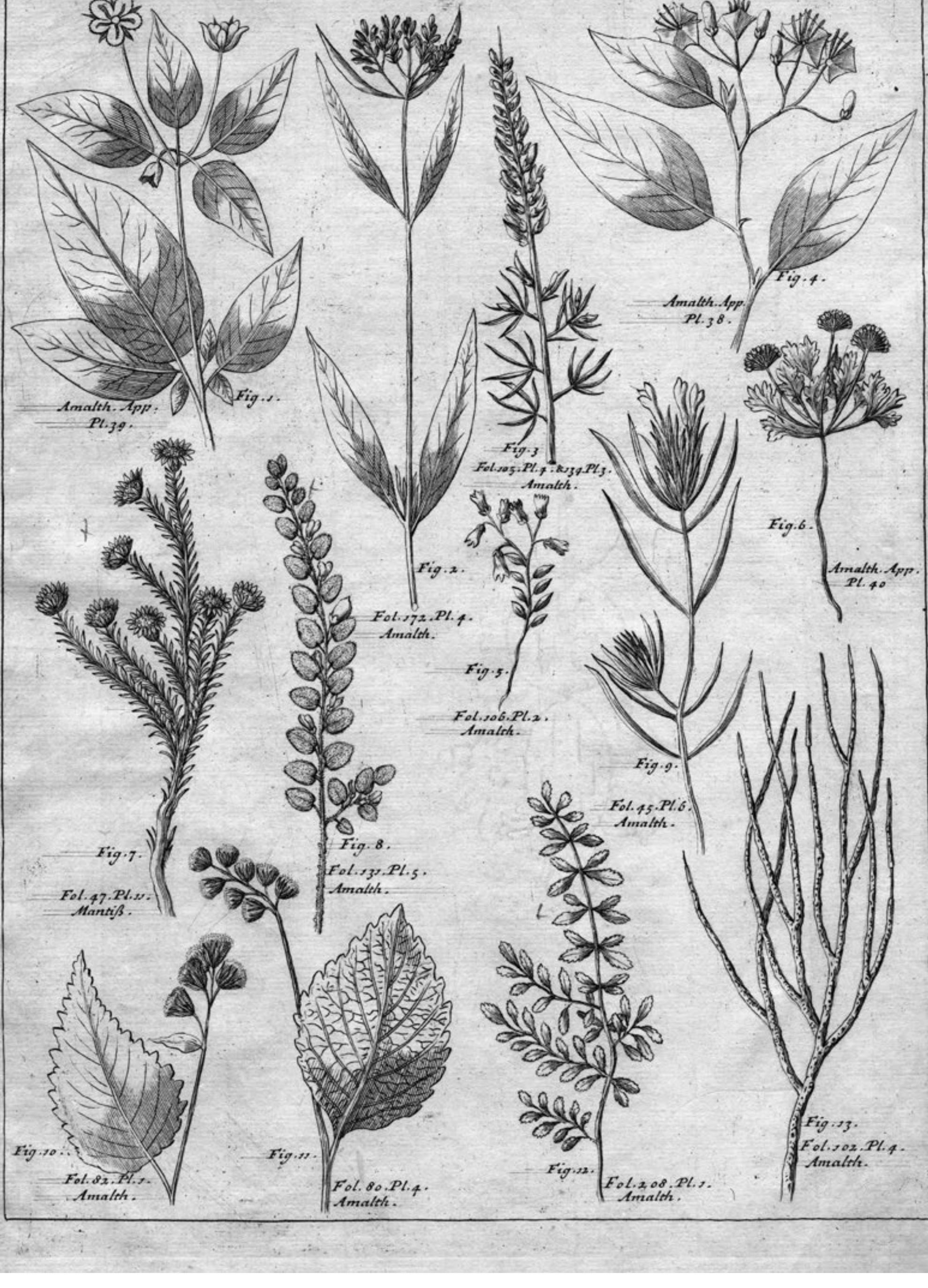
Today, scientific botanical illustrations are frequently seen plucked from the contexts in which they were made, separated from the purposes for which they were created. Divorced in such a manner, illustrations become something sold to bolster heritage, reproduced to generate income or hung to facilitate a lifestyle. Reproductions of, or images inspired by, the works of such familiar natural-history illustrators as Maria Sibylla Merian, Georg Dionysius Ehret and Walter Hood Fitch adorn cards, wrapping paper and cosmetics packaging. However, the purpose of botanical illustration is not to be decorative, to peddle influence or to market products. It is art with a scientific purpose: to record, display and convey scientific data about plants. An effective botanical illustration need not be aesthetically pleasing, but it must be accurate. The combination of aesthetics and accuracy – as achieved by many of the great botanical illustrators – is a bonus. Interpretations of an image may change over time but, as accurately observed and recorded data, botanical illustrations are timeless scientific records. However, the evolution of and interplay between botanical illustration and scientific ideas are rich, complex and nuanced. The work of artists and scientists alike is modulated by the times, places and circumstances in which they work.

This book explores interchanges between science and art through botanical illustration since the mid-fifteenth century, the way botanical illustration has been used to communicate scientific information about plants, and how views of botanical imagery have changed. Chapter One focuses on scientific botanical illustration as a collaboration, emphasizing the methods used by illustrators and printers to present scientific data and ideas. Chapter Two introduces botanical illustration, from its Near Eastern

roots, in the context of such recurrent themes as portraits versus ideals, the role of illustrators' prior knowledge, and the integration of images and text. Chapter Three summarizes botanical history, focusing on illustrations in the presentation of key observations in naming and classification, physiology and experimentation, and evolution and genetics. Chapter Four concentrates on botanical illustration for the discovery of plant diversity during field expeditions. Rather than those illustrators who roam the world's wild places, Chapter Five is about illustrators who rely for their subjects on cultivated landscapes. The subjects of chapters Six, Seven and Eight are illustrators who use their skill to record the insides of plants, the way plants grow and the results of experiments that test botanical ideas. The final chapter is concerned with the use of illustrations for education and the dispersal of ideas about plant sciences.

The images presented in this book emphasize the scientific purposes of botanical illustrations. Consequently, preconceptions of botanical illustration as primarily an aesthetic discipline are confronted. Today, botanical illustrators' skill appears challenged by digital photography, the questions asked by plant scientists and the manner in which modern scientific data are recorded, stored and presented. However, botanical illustrators have constantly embraced the benefits offered by the technology of their times, for example optics and the potential of enhanced vision, chemistry and innovative pigments, or engineering and novel printing processes.

Plants, and images of them, are central to the global challenges we face today, such as feeding expanding populations, conserving the diversity of life on the planet and creating environmental resilience. The challenge for twenty-first-century botanical illustrators, and the scientists with whom they collaborate, is to use the strengths of traditional illustration and photography to create synergies that capture and store data and effectively transmit accurate information about plants to a great diversity of publics.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PLANT AND PAGE

> It is difficult to give them [flowers] the accuracy of attention necessary to see their beauty without drawing them; and still more difficult to draw them in any approximation to the truth before they change.
>
> JOHN RUSKIN, *Proserpina* (1875)[1]

Eighteenth-century merchants, physicians, military men and colonial administrators sent vast quantities of plants to European capitals as global explorers revelled in the diversity and economic potential of the natural world.[2] These plants, amassed as living collections in gardens and preserved as flattened, dried specimens in herbaria, became essential botanical tools as the century progressed. In 1705 Queen Mary's botanist, Leonard Plukenet, published the *Amaltheum botanicum* (Gallery of Plants), which included hundreds of plant images crammed into 104 copperplate etchings made by at least six engravers. The flat, almost diagrammatic images give little sense of how the plants appear in life. This was probably because of the subjects' novelty and the artists' unfamiliarity with fundamental plant structure, the interpretation of relationships among structures or even the use of herbarium specimens as models.

In the top right-hand corner of the last plate in the *Amaltheum* there is a sprig of a sort of potato collected in northeastern Brazil. The illustration shows three leaves, a handful of flowers and buds and, importantly, a prickle on the stem above the second leaf. This is one of twenty images based on herbarium specimens the one-time privateer William Dampier collected and brought back to England from his government-funded circumnavigation of the globe between 1699 and 1701.[3] These Australian, Brazilian and

Twelve plants and a zoophyte from Leonard Plukenet's *Amaltheum botanicum* (1705). These images were drawn and etched based on dried specimens sent to Plukenet from Africa, Australia, Brazil, China, India and North America. The plants are arranged haphazardly on the plate, perhaps according to the order in which they were received or how they were most conveniently, rather than systematically, fitted into the available space.

Southeast Asian specimens were lent to Plukenet and his artists by Dampier's 'great friend, the erudite' English naturalist John Woodward.[4]

For more than a century Plukenet's image of Dampier's Brazilian potato was overlooked, until, in 1813, the French botanist Michel Dunal formally described it as a new species (*Solanum brasilianum*). However, the species was known only from Plukenet's image, and, despite people searching for decades, living examples were never found.

Dunal relied on the skill of an unknown artist to interpret Dampier's specimen, but nobody, including Dunal, bothered investigating the specimen that had been used as the model. More than two hundred years after Dunal's description, the specimen was rediscovered in the Oxford University Herbaria, among other dried plants collected by Dampier. When the specimen was re-examined, it became obvious that the artist had made a mistake, and that the prickle was in fact a displaced bud. Moreover, the specimen was of one of the most common *Solanum* species in Brazil. Dunal's species was not extinct; it had never existed.[5] The illustrator had inadvertently started a visual 'Chinese whisper', propagated by a botanist under the assumption that the model had been depicted accurately.

William Dampier's herbarium specimen of *Solanum paniculatum*, collected in northeastern Brazil in 1699, was used as the model for the etching published in Plukenet's *Amaltheum botanicum* (1705). The misinterpretation of a bud, introduced by the illustrator and/or engraver, and reliance by a botanist on this illustration led to the publication of a new species name for a common species that was already known.

What is botanical illustration?

A botanical illustration is a detailed, scientifically accurate representation that captures a plant's transient, sometimes fragile structure. The nineteenth-century French artist Antoine Pascal, writing about techniques of botanical illustration adopted by the renowned Belgian illustrator Pierre-Joseph Redouté, considered 'flower painting to have three purposes: it has immediate application to industry; is used to demonstrate botany; and is an object of art.'[6]

Important factors in effective scientific botanical illustration are naturalism and accuracy, based on detailed, first-hand observation. The prolific nineteenth-century Scottish botanical illustrator Walter Hood Fitch emphasized these points:

> strictly botanical drawing generally represents but one or two individual plants, and they must be equally correctly drawn and coloured. A fancy drawing or group in proportion to the number of plants introduced may have the details judiciously slurred over, for the eye of the observer cannot comprehend the minute points of all at a glance, so there is no labour lost. I may state that this dependence upon the carelessness of the observer is very frequently carried too far – and if at all times far from flattering, is often offensive; and that the works of many professors of flower drawing are not calculated to improve the public taste for the domain of Flora.[7]

Consequently, one immediate criterion to assess the quality of a botanical illustration is whether the plant depicted is readily identified based on the image alone.

The imaginative oil portraits constructed by the Italian painter Giuseppe Arcimboldo from flowers, fruit and seeds in his *The Four Seasons* (1563, 1572–3) series satisfy this criterion.[8] Individual elements are painted with such precision and accuracy that reliable identification is possible. In contrast, such series of floral paintings as Vincent van Gogh's *Sunflowers* (1880s) or Claude Monet's *Water Lilies* (1890s–1920s) fail the test. Van Gogh's and Monet's plants can be readily placed into broad taxonomic groups, but it is impossible to see the subtle, often minute features that distinguish species.

The permanent depiction of plants arose in many cultures, among them those of ancient Greece, Egypt, Assyria and China. Despite the fact that naturalistic botanical images have illustrated Chinese *materia medica* since at least the first millennium of the Common Era, the 'identifiability' criterion is associated with the birthplace of Western science – the eastern Mediterranean – and the rise of humanism.[9] Such images only gradually become part of Western scientific approaches to understanding the natural

world, while intercultural contacts inevitably modified Western botanical illustration practice. For example, seventeenth- and eighteenth-century Jesuit missionaries to China moved European and Chinese botanical illustrations east and west, respectively, while indigenous illustrators made major contributions to the European classification of plants in eighteenth-century India.[10]

Accuracy and technical competency alone are insufficient to make a botanical illustration scientifically useful. Exquisite botanical illustrations abound in libraries and archives, yet they may fail the scientific-value test because they lack associated metadata – the context within which they can be interpreted – for example, when and where they were made, and by whom. Moreover, unpublished illustrations never become formal parts of scientific discourses generated through critical peer review. The full scientific value of an illustration derives from its accuracy, the data accompanying it and the physical specimens supporting it, together with proliferation, circulation, study, review and criticism by scientific communities.

The Victorian naturalist Richard Spruce spent fifteen years exploring mountains and forests in the Amazonian region of northern South America. As he travelled, he collected specimens and artefacts that today stock European and North American cultural collections. Spruce's particular personal interests were the liverworts: small, delicate plants that are related to mosses and inhabit forest floors, tree trunks and the margins of streams and pools. Once back in Britain, he spent years cataloguing and describing his discoveries in forms acceptable to Victorian scientific conventions. His *Hepaticae Amazonica et Andinae* (Liverworts of Amazonia and the Andes, 1884) catalogues hundreds of species, supported by 22 plates of lithographed illustrations by the leading English bryologist Robert Braithwaite and the English mycologist and botanist George Edward Massee, with whom Spruce worked closely.[11] Despite his illustrators' natural-history credentials, Spruce had one advantage: he had studied the living plants in the field, rather than knowing them only from dried fragments resurrected in hot water. It is hardly surprising, therefore, that in his correspondence with Braithwaite, Spruce should highlight the 'excellent figures of hepaticae [liverworts]', but emphasized that he could have done more to help – 'If I had been near you I might have aided you in the selection of objects.'[12] Spruce would perhaps then have identified the illustrations

made from specimens distorted by 'repeated moistening and drying' at an earlier stage, or prevented them from ever being made at all.

The most scientifically valuable botanical illustrations emerge from a close collaboration among scientist, illustrator and printer, as the eighteenth-century Swedish naturalist Carolus Linnaeus emphasized: 'a draughtsman, an engraver and a botanist are equally necessary to produce a praiseworthy figure; if any of these is at fault, the figure turns out flawed.'[13] A scientist may provide an object or articulate an idea requiring illustration. An illustrator takes that vision, using living or dead plants to create physical images. To become part of scientific discussion, an illustrator's work must be transformed into a medium that can be readily circulated; historically, this has been print on paper. One skilled botanist and botanical illustrator put the relationship bluntly: 'making sketches, and figures for reproduction that can be cut in recognizable form by the engraver, are two very different propositions,' yet both (or their present-day equivalents) are essential.[14]

Scientist, illustrator and printer may be one and the same individual. For example, James De Carle Sowerby – perhaps the most talented member of the Sowerby family, nineteenth-century owners of a London print shop specializing in natural-history printing – was praised by the Royal Geological Society of London for 'illustrating our works with drawings and engravings of fossils[,] shells and plants, expressing their characters with a degree of accuracy and truth, which no pencil or burin but those of a scientific artist could possibly accomplish.'[15] More frequently, roles are divided as each relies on complementary skills that are rarely possessed by one person. The publication of botanical illustrations, then, is always a collaboration.

Importantly, editing of the original models happens at each step of the process, as features are removed, rotated, infilled, obscured, emphasized and resized according to the purpose of the illustration, the intentions of the author and the available technology. Moreover, each step of this editorial process erodes or accentuates botanical detail. Scientific interpretation of an illustration, and hence the limits placed on the conclusions drawn from it, are determined by the purpose of the illustration's production and the skill of both illustrator and printer.

Notwithstanding such concerns, several general trends may be discerned in botanical illustration from the fifteenth century onwards. These


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are associated with the methods and surfaces upon which illustrators capture images; the range and origins of pigments used to create colours; the use of magnification to enhance or expose new detail; the diversity of subject matter; and the audience for botanical illustration.

Arbiters of taste may relegate botanical illustration to mere technical drawing constrained by strict rules, where artistic expression has no business, and it is sometimes caricatured as a skilled mechanical operating a pencil or brush. One perception of the illustrator–artist dichotomy, from a professional botanical illustrator, has been stated thus: 'portraits intended for publication are generally referred to as "illustrations", a word [that is] sometimes used pejoratively as if "illustration" should inevitably be placed in a lower category than "art".'[17] An authority on botanical illustration presented the illustrator's position as someone 'contracted to do the illustration [but who] has no freedom whatsoever in the work – no possibility of self-expression – and works in the same way as a camera.'[18]

Since the adoption of the printing press in Europe in the fifteenth century, the diversity of high-quality published botanical illustrations demonstrates the artistic freedom brought to the constraints imposed by the scientific depiction of plants. An illustrator's mastery of their medium and their artistic choices add dramatically to the overall appeal, visual impact and scientific purpose of an illustration. In skilled hands, even the most arcane botanical objects are rendered informative, intriguing, thought-provoking and aesthetically pleasing.

Why draw plants?

Fundamentally, botanical illustrations are concerned with the preservation of scientific data, the presentation of information and the dissemination of knowledge. Importantly, botanical illustrations conserve data about plants that may be difficult to preserve using traditional museum techniques. The succulent form of a barrel cactus, the intricate shape of an orchid flower, the subtle colour of a pineapple and the three-dimensional structure of an acacia tree are all lost when these objects are pressed and dried, for example.[19] Broad areas of plant sciences have attracted the skill of botanical illustrators, among them the discovery, description and cataloguing of wild and cultivated plants, unravelling the arrangement of tissues that

Western Australian green seaweed, *Struvea plumosa*, from the Irish botanist and phycologist William Henry Harvey's five-volume *Phycologia Australica* (History of Australian Seaweeds, 1858–63). The plate, drawn and lithographed by Harvey, shows an algal fragment, at natural size, as it would appear floating in water, together with magnified portions of branches and reproductive structures. Harvey commiserated with people who are interested in seaweeds, since identification 'often requires a microscopical examination', but 'generic types are not very numerous, and when once known, are easily remembered and discriminated.'[16]

make up a plant's body, investigating how and where plants grow, and, of course, teaching. The nineteenth-century naturalist and artist William Burchell went beyond this list to emphasize that those who

> propose to visit countries little known, or seldom frequented . . . [should] regard the art of drawing as of the highest importance; not merely as the means of giving their friends an idea of those scenes and objects which they have beheld, but for their own gratification, and for the pleasure of a renewal of past impressions far more lively than any pen can render a written journal.[20]

Burchell's comments presaged the present-day use of the photograph.

As scientific evidence, a botanical illustration must be an accurate representation of a specimen based on objective, personal observations. The woodcut of 'Wassernuß' (water nut) in Hieronymus Bock's *De stirpium* (Of the Races, 1552) is an imaginative chimaera; it matches no known plant. Neither the illustration nor the accompanying text would aid anyone unfamiliar with the water caltrop to recognize the plant, although the separate fruit included in the cut appears to be that of water caltrop.[21] Likewise, unless readers of the Scottish surgeon and botanist William Roxburgh's description of water caltrop in *Plants of the Coast of Coromandel* (1819) were competent botanists, they would be confused until they studied the accompanying illustration:

> *Leaves* petiolated, approximate round the apex of the shoots; of a rhomboidal-reniform shape, with the posterior margins entire, and the anterior serrate-dentate; above smooth, deep green; villous and purple beneath; from 3 to 4 inches broad, and scarce so long. Petioles villous, lengthening with the age of the leaves; towards the apex much swollen: this part contains many inflated vesicles, which render the whole plant very buoyant.[22]

Botanical illustrations, like the specimens on which they may be based, are not benign objects; they may reveal complex patterns of social relationships, patronage and power. Botanical illustrators and naturalists, like their peers, often rely on the support of governments, aristocracies and

Woodcut, by David Kandel, of an imaginary 'Wassernuß' from Hieronymus Bock's *De stirpium* (1552), based on a watercolour by Albrecht Meyer. Plants of European reed mace are shown in the background. In the foreground, two reed-mace flower spikes, presented on grass-like stems, are decorated with rings of leaves that resemble those of either water caltrop or ground ivy, together with water-caltrop fruit. Views of a detached fruit (right) and an extracted seed are also shown.

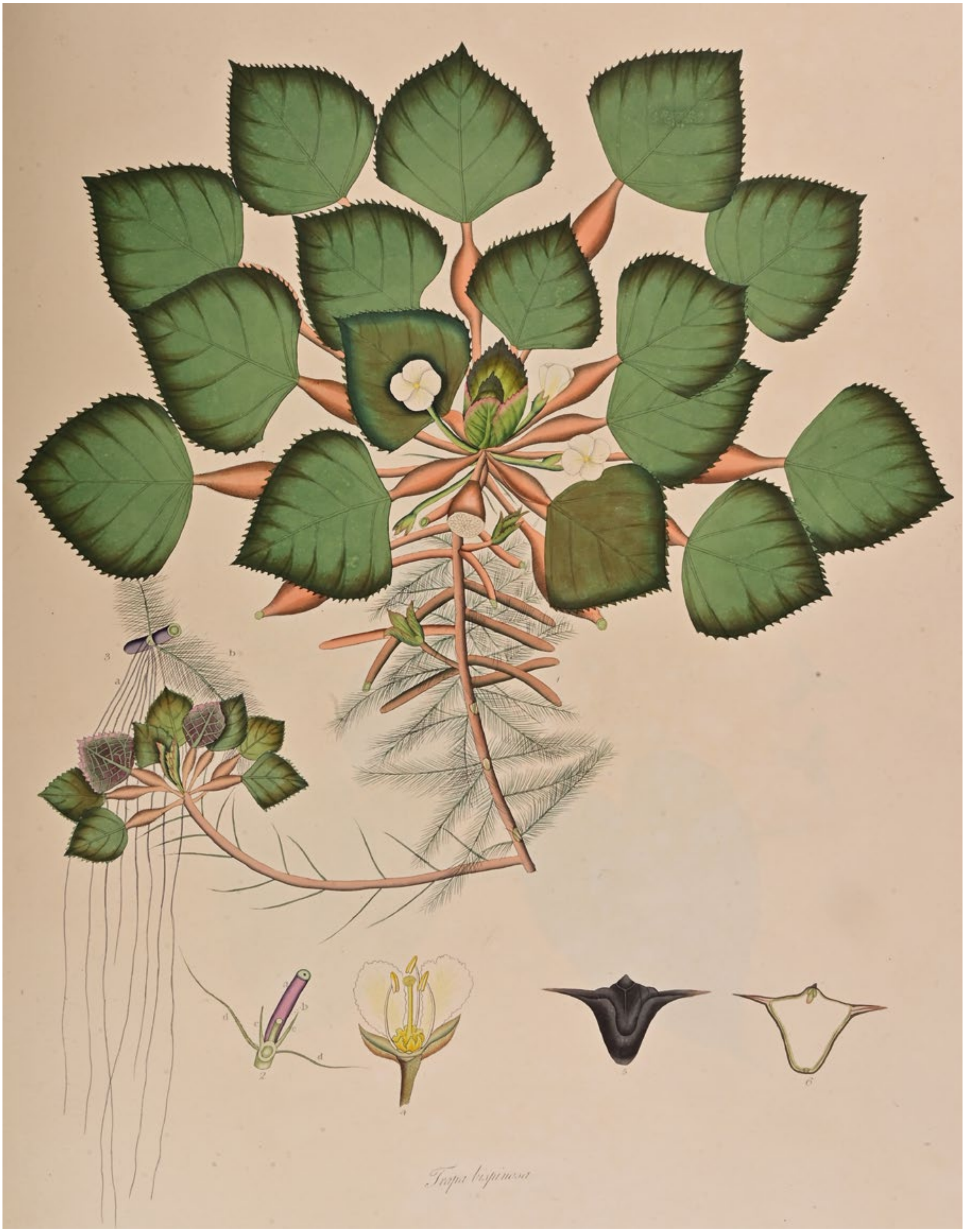
commercial interests. In the 1830s the botanist John Lindley drew his readers' attention to such issues when he published orchid illustrations by Franz Bauer:

> To make the whole of such splendid specimens of art public by means of engravings capable of expressing the beauty of the originals, would be an object worthy of a liberal Monarch and an enlightened Government; to a private individual the large expense must necessarily prove an insuperable impediment. To publish a selection of such as throw the greatest light upon structure is all that so humble an individual as myself could venture to undertake, and even this the little encouragement given to such undertakings has obliged me to extend through a period of some years.[23]

Bauer had been patronized by Joseph Banks, the intellectual architect of the Royal Botanic Gardens, Kew, since his arrival in England from Austria-Hungary in the late eighteenth century.

Between 1795 and 1819 the British East India Company selected three hundred botanical illustrations from among thousands made by Mughal artists under Roxburgh's guidance for publication as folio-sized, hand-coloured copperplate engravings in *Plants of the Coast of Coromandel*. The Company had two motives for its largesse: 'to promote science in India'; and as 'an example for the encouragement of the Company's servants abroad, to dedicate their leisure hours to useful research, as a means of recommendation to the notice of their superiors, as well as of obtaining a well earned reputation in their native country'.[24]

The addition of illustrations, especially coloured ones, could make a book appealing, but sometimes at considerable cost. Lavish, limited-edition productions, such as *Plants of the Coast of Coromandel*, are at one end of a price spectrum for illustrated botanical books. At the other end are text-books, identification guides and teaching aids, whose illustrations are utilitarian, designed to enhance clarity or promote sales. For example, on the spine of the fifth edition of John Hutton Balfour's *A Manual of Botany* (1875; 1st edn 1848), one of the standard British botanical teaching texts in the latter half of the nineteenth century, the phrase '963 illustrations' was displayed prominently in a typeface almost as large as that of the



Hand-coloured copperplate engraving of Indian water caltrops made from an original watercolour by an unknown Mughal Indian artist, working for the Scottish surgeon William Roxburgh, botanist to the British East India Company. The main image shows the plant's leaves symmetrically arranged, in a manner reminiscent of Mughal art, together with roots 'floating on sweet standing water, over Bengal'.[25] Magnified dissections of a flower and fruit are also included.

author's name. On the title page, the specific number of black-and-white illustrations was replaced with a less certain 'upwards of nine hundred illustrations'. The implication is clear: illustrations promote sales.

Who draws plants?

Published botanical illustrations are adroit, creative collaborations among artists, naturalists and printers, whereby reliable data are recorded, preserved and transferred within and across generations. Yet a popular stereotype persists of botanical illustrators as ladies in need of distraction, 'to whom the study, from its delicacy, is peculiarly appropriate'.[26] Moreover, the teacher and artist Frederick Edward Hulme – a man apparently with little knowledge of the antecedents of his subject – suggested that illustrating plants was easier and less tiresome than depicting landscapes or the human form, which 'must all be sought out and striven after with patient assiduity . . . The flower-painter need fear no glaring sun, no fatiguing walk, no burden of the necessary impedimenta, but in the quiet of his or her own room may strive with more or less success to depict the beautiful forms and tints before them.'[27] In the mid-nineteenth century Charles Dickens traded on the prejudice in his presentation of Dora Spenlow – David Copperfield's first wife – as an unworldly young woman of a particular social background, whiling away her days painting flowers, playing the guitar and pampering her dog, Jip.

Decades earlier, the Scottish botanist and garden writer John Claudius Loudon asserted that 'to be able to draw Flowers botanically, and fruit horticulturally . . . is one of the most useful accomplishments of young ladies of leisure, living in the country.'[28] He congratulated the men in charge of British plant nurseries for having their daughters taught to make 'scientific portraits', adding that of 'all the mechanical trades, drawing is perhaps of more use than either writing or arithmetic'. Naturalist fathers training their daughters to draw was not unusual. In the late seventeenth century the English physician and naturalist Martin Lister cultivated the talents of his daughters Anne and Susanna as they drew and engraved the figures for his publications.[29] Harriet Anne Thiselton-Dyer, daughter of Joseph Dalton Hooker (who succeeded his father, William Jackson Hooker, and preceded his son-in-law William Turner Thiselton-Dyer as director of

Kew), used her drawing skill to become one of the outstanding professional botanical illustrators of the late nineteenth and early twentieth centuries.[30] Despite men dominating lists of botanical discoveries, science dependent on botanical illustration is littered with women's achievements, although their contributions often go unacknowledged or are at least less prominent than their talents or contributions deserve.[31]

For many botanical artists to thrive, professional payment or patronage is essential. The work of Mark Catesby, the eighteenth-century illustrator of the flora and fauna of the southern United States, was supported by a cartel of British naturalists and physicians.[32] Ferdinand Bauer, brother of Franz, was supported by the botanist John Sibthorp.[33] Redouté prospered under the patronage of Marie Antoinette and Joséphine Bonaparte.[34] The Danish botanist and surgeon Nathaniel Wolff Wallich made ample use of the skill of three Indian artists (Gorachand, Vishnupersaud and Rungiah) he employed at the Calcutta Botanic Garden for the 294 plates that illustrate his three-volume, folio-sized *Plantae Asiaticae rariores* (Rare Asiatic Plants, 1830–32). Moreover, the persistence of the Indian artists and their skill at handling colour prompted specific comment from at least one colonial administrator:

> The native of the Punjab . . . has an instinctive appreciation of colour, and though without any knowledge of the principles which should regulate its use, is often more happy in his combinations than the educated workman of Europe. His color is often exaggerated but it is always warm, and rich and fearless. The native artist is also patient: for weeks and months he will work at his design, painfully elaborating the most minute details; no time is considered too long, no labour too intense to secure perfection in imitation or delicacy in execution. The greatest failing in native artists is their ignorance of perspective and drawing, and it is fortunate that this want is the most easy to supply.[35]

Talented artists may also be nurtured into botanical illustration. As a youth, the Welshman Moses Griffith's artistic talents were recognized and developed in the service of his countryman the naturalist and antiquarian Thomas Pennant. In 1772, about three years after entering Pennant's service,

The ‘Pictores operis’ and ‘Sculptor’ from Leonard Fuchs’s *De historia stirpium commentarii insignes* (1542). Before the ‘Pictores operis’ is a vase of flowers, including a spray of corncockle; Albrecht Meyer is drawing, apparently from life, while Heinrich Füllmaurer copies a drawing on to the plank-face of a woodblock. The block would eventually be cut by the woodcutter Veit Rudolph Speckle, who seems to ‘compete with the painter for glory and victory’.[36]

Griffith joined his master on a tour of Scotland in the company of the English clergyman and naturalist John Lightfoot. During that tour Griffith made drawings of plants and animals, which were engraved by the Irish painter Peter Mazell and published in Lightfoot’s two-volume *Flora Scotica* (1777).

The first published, visual recognition of the explicit collaboration among artisans in the publication of botanical illustrations is that of the team who spent more than a decade preparing over five hundred woodcuts for the German physician Leonard Fuchs’s *De historia stirpium commentarii insignes* (Remarkable Commentaries on the History of Plants, 1542), one of the foremost botanical works of the sixteenth century. These men were professionals – they earned their livelihoods from drawing and woodcutting – who gradually learned to depict plants at their best.[37]

Such examples show that popular assumptions about who makes botanical illustrations, together with associations between illustration and gender, leisure and class, and amateur and professional statuses, are nuanced, complex and frequently misrepresented.

Where are plants drawn?

The places in which botanical illustrators choose, or are required, to draw their subjects are as varied as the artists themselves. Take three siblings who were exceptional professional botanical illustrators in the late eighteenth and early nineteenth centuries: Joseph, Franz and Ferdinand Bauer. Joseph worked in Austria and Liechtenstein. Ferdinand created watercolours in Oxford and London, based on sketches made during expeditions through the eastern Mediterranean and Australia, while Franz was based in a studio and laboratory at the Royal Botanic Gardens, Kew.[38]

Drawings complement the written records of eighteenth- and nineteenth-century voyages of trade, colonization and discovery. Often the drawing skills were those of an accomplished amateur, perhaps acquired through a gentleman's education. Sometimes the role became professional when specific individuals were hired as natural-history illustrators. For example, the Scotsman Sydney Parkinson made more than 1,500 botanical sketches and paintings as Joseph Banks's natural-history illustrator on James Cook's voyage on the *Endeavour* to Australia and the Pacific in 1768–71.[39] The German aristocrat and naturalist Georg Heinrich von Langsdorff led a Russian-funded scientific expedition in 1824–9 to explore Brazil by boat from São Paulo in the southeast to Pará in the north.[40] Two professional artists, Johann Moritz Rugendas of Germany and the Frenchman Adrien Taunay, were part of the expedition team, although Rugendas abandoned the expedition in 1826 and Taunay was drowned two years later.

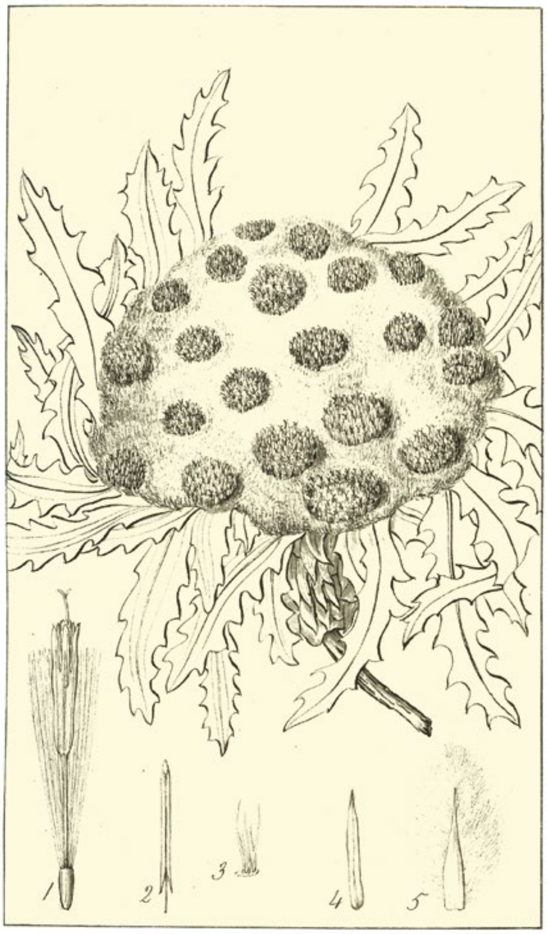
Rather than the peripatetic lifestyle afforded to an expedition illustrator, some illustrators settled for protracted periods where they were working. The German-Dutch naturalist Maria Sibylla Merian stayed in Suriname for two years (1699–1701), illustrating its plants and insects.[41] In Dutch Brazil, another Dutch West Indian Company colony (now the area around Recife), the Dutch artist Frans Janszoon Post spent seven years drawing the local flora, fauna and landscapes, under the patronage of the colony's governor, Johan Maurits of Nassau.[42]

In other cases, rather than travelling, illustrators relied on plants coming to them as museum specimens or living plants grown in gardens. For example, the French botanist Jacques-Philippe Cornut wrote the first account of Canadian plants, *Canadensium Plantarum* (1635), which was illustrated with plates attributed to the French artist Pierre Vallet.[43] However, neither botanist nor artist visited Canada; they both worked with living and dead specimens brought to the Jardin du Roi in Paris from France's North American possessions. Similarly, Redouté is best known for his illustrations of the plants that graced Joséphine Bonaparte's garden at Malmaison.

Pen-and-ink drawing of a Himalayan saw-wort, *Saussurea simpsoniana*, by Mary Maria Fielding, together with the specimen from her husband Henry's herbarium that she used as a model. The details of flowers and hairs on the drawing were probably added by George Gardner. The specimen was collected from northwestern India by Lieutenant R. S. Simpson of the Bengal Native Infantry in 1836. The formal description of the species, accompanied by a lithograph of Mary's illustration, was published in Fielding and Gardner's *Sertum plantarum* (1844); its scientific name commemorates the collector.

Making illustrations

Whoever illustrators are or wherever they work, they make choices about how to record a botanical subject. Their decisions are influenced by their mastery of techniques, the working conditions in which they find themselves, the type of subject they are depicting, a researcher's needs and how the image will be published. Despite the variety of media available, three methods predominate: pencil, pen and ink, and watercolour. However, the function of a botanical illustration, and its acceptance by an intended audience, may be affected by the medium in which it is made or transmitted. For example, plant identification guides with black-and-white images may be less useful than those with colour images, unless an audience is familiar with the interpretation of botanical illustrations.[44]



The nineteenth-century English botanical illustrator Mary Maria Fielding used pen and ink to depict rare and unusual plants acquired by her husband, the botanist Henry Borron Fielding.[45] Her models were the herbarium specimens, collected by field botanists across the tropics, which her husband purchased at auctions. In contrast to the artist who drew Dampier's Brazilian potato, Mary, who also knew her subjects only from flattened specimens, managed to give a sense of the living plant's three-dimensional structure. Most of her 445 pen-and-ink drawings were eventually published in her husband's *Sertum Plantarum, or Drawings and Descriptions of Rare and Undescribed Plants from the Author's Herbarium* (1844, 1849); the approximately 530 watercolours she made of the British flora have never been published.[46]

The early nineteenth century brought the publication of many practical manuals of botanical drawing and watercolour, among them Patrick Syme's *Practical Directions for Learning Flower Drawing* (1810), Edward Pretty's *A Practical Essay on Flower Painting in Water Colours* (1810) and James Andrews's *Lessons in Flower Painting: A Series of Easy and Progressive Studies, Drawn and Coloured after Nature* (1836).[47] These often took the form of copybooks. The English novelist and artist Henrietta Maria Moriarty published *Fifty Plates of Green-House Plants* (1807), which was intended for the 'improvement of young ladies in the art of drawing'. Rather than original works, many of Moriarty's plates were indifferently copied from the *Botanical Magazine*, which regularly published hand-coloured engravings of exotic plants grown in British gardens.

In 1869 Walter Fitch distilled decades of practical experience, having professionally drawn thousands of plant species, into eight short articles, illustrated with wood engravings, for the *Gardeners' Chronicle*.[48] Fitch, 'more accustomed to the pencil than the pen',[49] was forthright in his view that draughtsmanship was essential in botanical illustration: 'facility in colouring is easily acquired, but a correct eye for drawing is only to be rendered by constant observation.' Moreover,

> correct drawing and colouring should be found in the same work, for the absence of the former cannot be compensated [for] by any excellence in the latter. Most beginners in flower drawing are desirous of rushing into colour before they can sketch

Charlotte Georgina Trower's watercolour of a yellow archangel plant collected in Devon in April 1912. Trower was a Hertfordshire landowner who, for the last 21 years of her life, collaborated with the Oxford-based amateur botanist George Claridge Druce to produce more than 1,800 watercolours of plants in the British flora.

> – unaware that the most gorgeous daub, however laboured, if incorrectly drawn is only a crude effort at 'paper staining'.

A reviewer of John Cart Burgess's *A Practical Essay on the Art of Flower Painting* (1811) had expressed a similar view more than fifty years earlier: 'our Misses and Masters are apt to think themselves perfectly *au fait* at flower painting, provided they can daub over a rose or a wreath of non-descripts.'[50] Fitch believed the method he described was 'applicable equally to drawing dried as well as living plants'.[51]

Central to Fitch's approach to botanical illustration was accuracy and attention to detail, which required that the illustrator have some botanical knowledge. Manuals of botanical illustration had to be more than lists of names; they had to improve the reader's knowledge of fundamental plant structure: 'I have frequently seen such negatively instructive illustrations of ignorance, – quite inexcusable, for a little knowledge would enable them to be avoided. It is more creditable that one's work should furnish an example than a warning.'[52] Today, naturalistic illustration is aided not only by knowledge of form but by an understanding of function and evolution.

Fitch argued that adding colour to an illustration was a simple process, but for centuries the accurate representation of a living plant's colour has exercised artists and botanists, and especially gardeners – where slight differences in hue may separate profitable from non-profitable cultivars.[53] Moreover, the very best botanical colourists learned to make best use of the potentially limited array of raw materials in their palettes.[54]

Traced ink drawing of a sprig of Chinese mallow from Ming dynasty Wang Shichang and colleagues' *Bencao pinhui jingyao* ('Materia medica Containing Essential and Important Material Arranged in Systematic Order', completed 1505). In the *bencao* this plant is claimed to be a diuretic and laxative, as well as increasing lactation and draining pus.

Reproducing illustrations

The diffusion of mechanical printing from mid-fifteenth-century Europe, combined with changes in paper, ink and moveable type technology and the development of the printing press, is associated with profound global social, political and economic events.[55] However, printing, paper, ink and moveable type are not European technology; they have their origins in China and eastern Asia.[56] Chinese *bencao* (*materia medica* or herbals) from as early as the Northern Song period (960–1127 CE) contain thousands of monochrome and polychrome plant illustrations, reproduced using printed woodblocks.[57] Global attention was drawn to the enduring value of these images and the associated text, following the discovery that the traditional Chinese medicinal plant *qinghao* (*Artemisia annua*) is a source of an effective antimalarial drug, artemisinin.[58]

Relief, intaglio and planographic printing are three fundamentally different methods of transferring patterns of ink between flat surfaces.[59] In relief printing, ink is carried on the surface of a raised pattern. In intaglio printing, ink is carried in furrows and dimples marked into a printing surface, while planographic printing uses ink applied directly to a printing surface. Woodblocks were used regularly to illustrate books until the mid-nineteenth century, since their raised reliefs were readily combined with moveable type to assemble pages for the printing press. During the seventeenth and eighteenth centuries intaglio printing competed with relief printing, before both were gradually supplanted by planographic methods from the early nineteenth century onwards.

Relief printing

A woodblock has two faces: the plank face, which runs parallel to the grain, and the end face, which is perpendicular to the grain. Woodcuts are made on the plank face of softwood, such as pine, or hardwood, such as poplar and apple, using knives, gouges and chisels. A similar process is used in wood engraving, although the artisan uses finer instruments, such as gravers, to carve the end face of high-density, fine-grained timber, such as box.[60] In both cases, anything that will not be printed in the final image is removed; the lines making the image are raised above the surface of the block. The type of wood and choice of face affect the quality of a printed illustration through the smoothness of the cutting surface, the fineness of the lines that can be achieved, and the mechanical properties of the block during the printing process.

The German physician and prelate Hieronymus Bock's *New Kreuterbuch* (New Plant Book, 1539), one of the earliest European printed herbals, is noted for its detailed plant descriptions and its absence of illustrations. However, in three later editions, published between 1546 and 1552, alongside the letterpress were printed hundreds of woodcuts by the German artist David Kandel. Many of Kandel's woodcuts used images from earlier German sources as models, while the artist's humour was displayed in original woodcuts, such as trees that include scenes of German rural life or allegorical imagery.[61] For example, a *Feigenbaum* (fig tree) is graphically augmented with a young man vomiting and defecating after consuming too many of

its fruit, while an apple tree, anachronistically laden with both fruit and blossom, comes complete with serpent, and human bones scattered among the windfalls.[62] Kandel's work also revealed the limitations of early woodcut techniques for representing plants, which included constraints imposed by the dimensions of the block, and line density and thickness associated with a woodblock's mechanical properties.

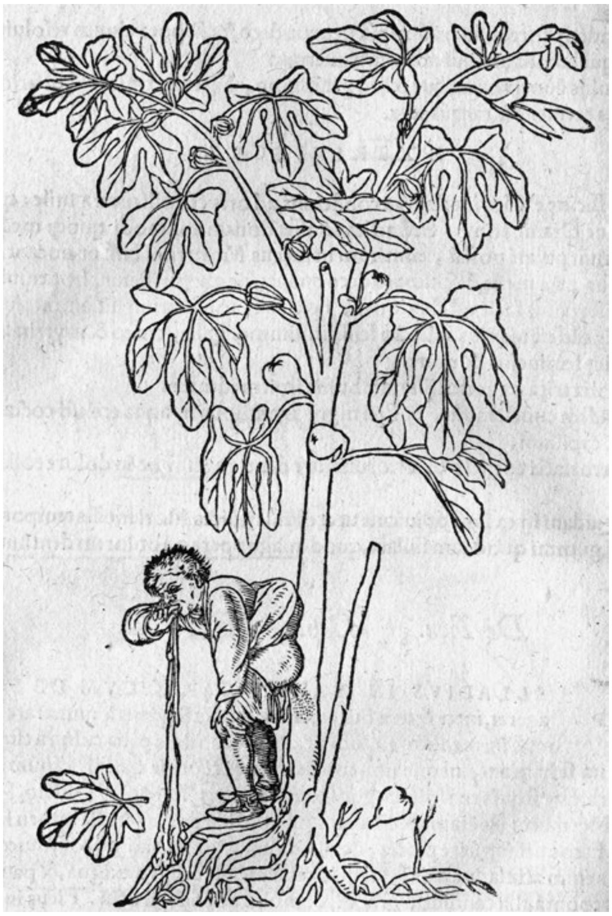


Fig tree from Hieronymus Bock's *De stirpium* (1552). David Kandel's woodcut shows a bare-rooted, fruit-laden tree in leaf. The separate leaf and fruit lack scale and detail, especially when compared with the portrayal of the man. The woodcut is set within a page of Latin text, produced as a single page of relief printing.

During the sixteenth century, as artisans applied new techniques to their craft, the complexity and subtlety of detail depicted in woodcuts increased, revealing the skill of often unacknowledged woodcut makers. In 1544 the first edition of the Italian physician and naturalist Pietro Andrea Mattioli's *Commentarii in sex libros Pedacii Dioscoridis* (Commentaries on the Six Books of Pedanius Dioscorides) was published. This book eventually went into fourteen editions and was translated into many European languages, with early editions apparently selling more than 32,000 copies.[63] One of the book's attractions was the elaborate woodcuts of later editions, published in Venice and Prague, that made full use of the area offered by the woodblock.

As woodcuts became more elaborate, they grew more laborious, slower and more expensive to make. In 1564 two-thirds of the production cost of a book published by the Antwerp-based printing house of Christophe Plantin was associated with the 139 woodcuts it contained.[64] As with present-day picture libraries, the cost could be reduced by reusing woodcuts across several publications.[65] The use of woodcuts to illustrate botanical publications declined during the seventeenth century as intaglio methods appeared to resolve the technical limitations associated with image resolution.

Apple tree 'Malvs Μηλέα' from Pietro Andrea Mattioli's *Commentarii in sex libros* of 1565. The woodcut of the bough, aesthetically and adeptly crammed into an area measuring 154 by 216 millimetres (6 by 8½ in.), shows fruit of different shapes from different angles and also, presumably to save space, flowers. The woodcut is highly decorative, but lacks a general sense of the appearance of an apple bough.

'Apocynum 'Ἀπόκυνον' from Fabio Colonna's *Phytobasanos* (1592). Colonna's concern for the illustrations in his book meant he was involved at all stages of the production. The metal engraving, surrounded by a decorative woodcut border, shows a rooted specimen, with both paired, five-petalled flowers and paired, bean-like fruit, arranged to fit the confines of the plate. The illustrator has misinterpreted the structure of this dogbane by having each flower produce one fruit. In fact, each flower produces two.

Intaglio printing

Grooves in sheets of soft metal, most commonly copper, are made using two primary methods: engraving and etching.[66] Metal engraving, as opposed to wood engraving, means removing those pieces of the plate that form the inked line using a graver (burin). The engraver pushes the sharp-pointed, V-shaped graver into the surface of the plate, then forces it along to scoop out a sliver of metal. By rotating the plate against the graver, curved grooves are created, while varying pressure on the graver creates grooves of different

thicknesses and depths. The thicker or deeper the groove, the more ink is held and the darker the line will appear on the printed page. However, the physicality of the process forces the engraver to work in certain ways, putting limits on the style of engraved images.

In contrast, etching is a chemical rather than a mechanical process, allowing the etcher to work more naturally than the engraver. The etcher coats a metal plate in acid-resistant wax, then scratches lines into the surface to expose the metal beneath. When the wax-coated plate is immersed in an acid bath, only the exposed metal is dissolved. The longer the acid 'bites', the deeper and wider the line and hence the darker the print. Part of the art of the etcher is the science of artfully controlling the action of acid on metal. Subtle tonal qualities may be added to intaglio plates using such techniques as stippling, mezzotint and aquatint.

Copper-etched botanical illustrations first appeared in Rome in the 1580s, made by the Milanese artisan Giovanni Ambrogio Brambilla and published by Pietro de' Nobili.[67] *Phytobasanos* (Plant Touchstone, 1592), by the 24-year-old Neapolitan naturalist Fabio Colonna, has a claim to be the first botanical work illustrated with metal etchings. It contains 37 full-page copperplate portraits (including four marine animals), each surrounded by a characteristic woodcut border printed in relief.[68] By the early seventeenth century, intaglio prints were recording finer detail than could be achieved using relief prints.

Intaglio printing is associated with the so-called golden age of botanical illustration, in the eighteenth century. Many of the most familiar of these works, often fantastically expensive when they were published, today command fabulous prices at auction. These trophy volumes were published to adorn the libraries of institutions and wealthy connoisseurs; they are not working documents for naturalists wrestling with recording and understanding plant diversity. One of the numerous damning reviews of Robert John Thornton's *Temple of Flora* (1807), an elaborately illustrated volume aimed at educating its readers in Linnaean botany, asserted that 'Expensive performances like this can recommend themselves only to persons, who, with a taste for the polite arts, possess also the means of indulging it; and to public libraries, the archives of what is curious in a country.'[69]

Price limits the circulation of intaglio prints, but the high pressure exerted by a rolling press – necessary to force paper into the inked grooves

of a plate – means that printing wears out the plate. Printed lines become faint and the quality of the image, independent of its scientific merits, is degraded. Consequently, print runs are short or the plates, particularly those made of copper, must be re-engraved, sometimes frequently. Hard steel plates allow many copies of a print to be produced but are more difficult to work than their copper equivalent.

Intaglio methods gradually limited the production of illustrated books, not least in terms of format, page composition and print run. For example, intaglio printing restricts the form of a book because the text is printed in relief. Consequently, text and images cannot appear on the same page unless the text is also engraved or etched. Images therefore become separated from the associated text, often accompanied by the familiar 'instructions to the binder' for where images are to be interleaved in a text block. Agnes Arber, the early twentieth-century expert on early modern printed botanical books, pointed out that, therefore,

> pictures are liable to become the primary feature of the work, and to lose their relation to the text, which then declines. The consequence is that books with fine engravings appeal rather to the wealthy amateur, whose influence is patent in the seventeenth-century botanical books, in which the theme shows a definite shift towards horticulture. The humbler woodcut . . . can be kept under firmer control, and is thus better fitted for the purposes of the working botanist. In the history of the science, illustration has, indeed, been the best of servants, but progress is inhibited when it usurps the master's place.[70]

The end of the eighteenth century brought a resurgence in wood being used to reproduce plant illustrations. By skilfully joining woodblocks together, wood engravers, who use the end face of a woodblock, achieved large, finely wrought illustrations capable of being reproduced many thousands of times with no loss in quality.[71] Moreover, illustrations could be incorporated into pages of printed text. The use of wood engravings finally declined with the widespread use of planographic techniques, particularly lithography.

Barbed goatgrass and canary grass from Johann Christian Daniel von Schreber's *Beschreibung der Gräser* (Description of Grasses, 1769) based on illustrations drawn from 'nature' by the German artist Christian Gottlieb Geyser. The hand-coloured copperplate, engraved by the German engraver Carl Leberecht Crusius in 1767, includes dissections of the grasses' floral parts.


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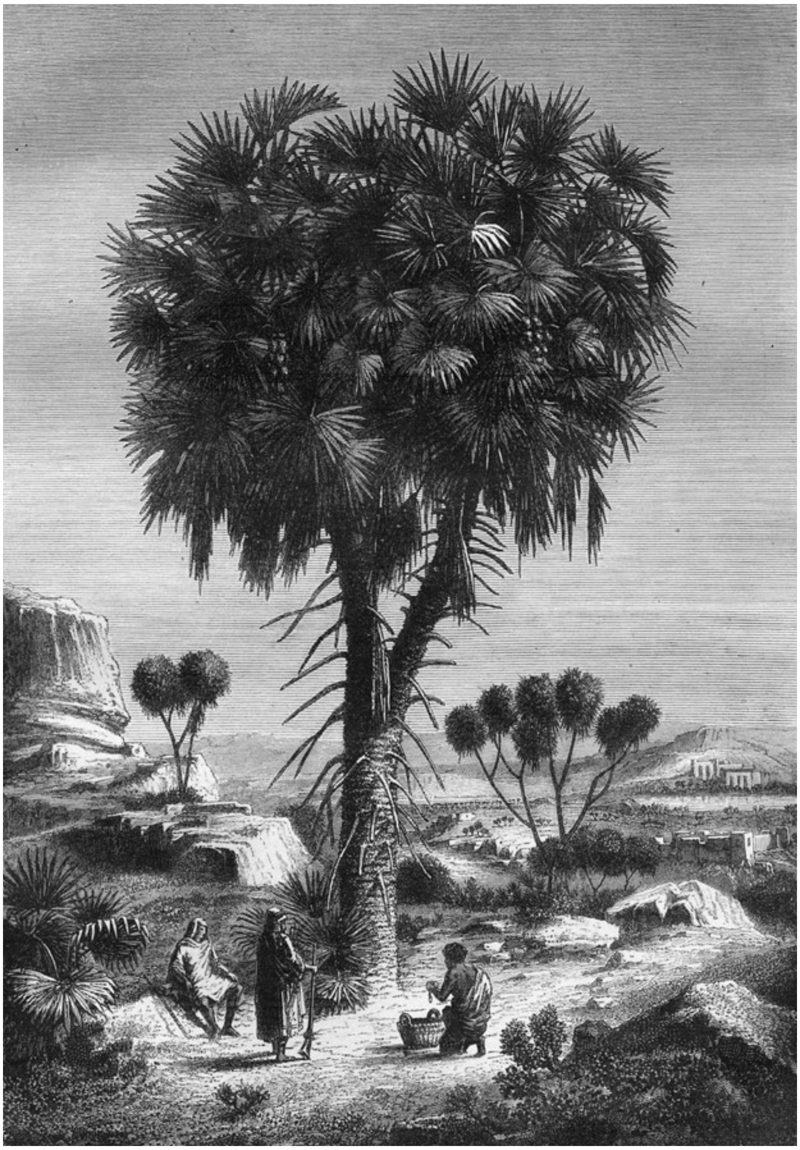
Fig. I
Fig. II
C. G. Geyser del.
C. L. Crusius fe. 1767.



'The doum palm of Upper Egypt', wood engraving by an unknown artist, based on an illustration by the French botanical illustrator Auguste Faguet. The image, published in the first volume of the Irish gardener William Robinson's *The Garden, an Illustrated Weekly Journal of Gardening in All Its Branches* in 1871, shows the palm within a stylized tableau.

Hand-coloured lithograph of two Himalayan members of the mint family, *Phlomis cashmeriana* and *Salvia hians*, from John Forbes Royle's *Illustrations of the Botany . . . of the Himalayan Mountains* (1839). In 1831 Royle retired as superintendent of the botanic garden at Saharanpur in Uttar Pradesh, where he had employed local artists to draw plants. These plants were drawn in India by Luchmun Sing. Sing's illustrations were transferred to 'stone' in London by the Maltese lithographer Maxim Gauci before being printed and finished by one of the numerous printing houses in the same city.

Planographic printing

In the 1790s the Bohemian playwright Alois Senefelder invented the first planographic printing process, lithography ('stone-writing'), a process that relies on the immiscibility of water and oil. He used smoothed blocks of limestone (the 'stone') from quarries near Solnhofen in Bavaria. An image is drawn on the surface of the stone with a wax crayon. The stone is then processed to ensure that when oily printer's ink is applied to the surface, it

sticks to the crayon but is repelled by the rest of the stone. Consequently, when a piece of paper is laid over the inked stone and passed through a press, the drawn image is transferred cleanly from stone to paper.

For the illustrator, the process of drawing on a stone is no more difficult than using a pencil; gone are the technical problems of creating images on relatively intractable surfaces, such as wood and metal. Indeed, the illustrator or botanist-illustrator could eliminate the intermediate step of creating a paper copy of an illustration by working directly on to the stone. However, the skill of the lithographic printer, as with printers of woodblocks and metal plates, remained essential to the publication of high-quality illustrations.

The Solnhofen quarries, famous for the discovery of the first complete skeleton of the feathered dinosaur *Archaeopteryx* in the 1860s, remain a source of lithography stones. However, by the end of the nineteenth century some metals, such as zinc and aluminium, were found to have similar hydrophilic and hydrophobic properties to limestone. Such materials increased in importance as costs fell and the production of printed illustrations became highly mechanized during the twentieth century.

In the 1830s John Lindley saw the technical limitations of lithography, compared to intaglio printing, but recognized that compromise was essential if illustrated books were to achieve wide circulation:

> It has been found indispensable to represent Mr [Franz] Bauer's drawings by means of lithography instead of engraving on copper; and unfortunately the former art, even in the most skilful hands, is seldom adapted to high finish or delicate touch; when executed by a mere amateur (as part of the plates has been) it is still less calculated for such an object. It is however hoped that the principal facts explained by the drawings have been faithfully represented, and that the defects of some of the plates as works of art will not be prejudicial to them as illustrations of science.[72]

By the mid-nineteenth century lithography was the primary means of reproducing botanical illustrations quickly and cheaply.[73] Moreover, illustrated botanical part-works being published across Europe, especially

those focused on garden plants, took advantage of the method to satisfy demand for illustrations of, and information about, plants.[74]

Nature printing

Recording and distributing nature as botanical illustrations is a slow process, prone to editing by artists and printers. Consequently, methods that provide rapid, precise – 'true' – representations of plants without the need for skill at drawing or printing are attractive. The botanical equivalent of brass rubbing, using either a soft pencil or a wax crayon, could give impressions of bark surfaces or leaves. However, before the prominence of photography, nature printing appeared to offer a better solution.

Nature printing is a collection of techniques that use the surfaces of natural objects to make direct prints without the formal involvement of an illustrator.[75] The use of direct printing from nature in Europe dates from at least the thirteenth century, although its use elsewhere is likely to be much older.[76] A dried, flattened plant specimen is coated with lampblack or printer's ink and firmly pressed against a piece of paper to leave an exact impression.[77] Some botanists, such as Fabio Colonna and Jacob Bobart the Younger, used the methods in their personal botanical notes and to supplement their collections of herbarium specimens, especially with examples of rarities.[78] Herbarium specimens of Central Asian wild apples made by twentieth-century Soviet plant collectors frequently include the outline of mature fruit made using the cut surface of bisected apples as stamps.[79] Beyond the sphere of private note-taking, eighteenth-century examples of nature-printed volumes include the German physician Johann Hieronymus Kniphof's three-volume *Botanici in originali seu Herbarium vivum* (Original Botany or the Living Herbarium, 1757–64). Since each sample could be used to make only a few prints, different copies of the same plate vary.

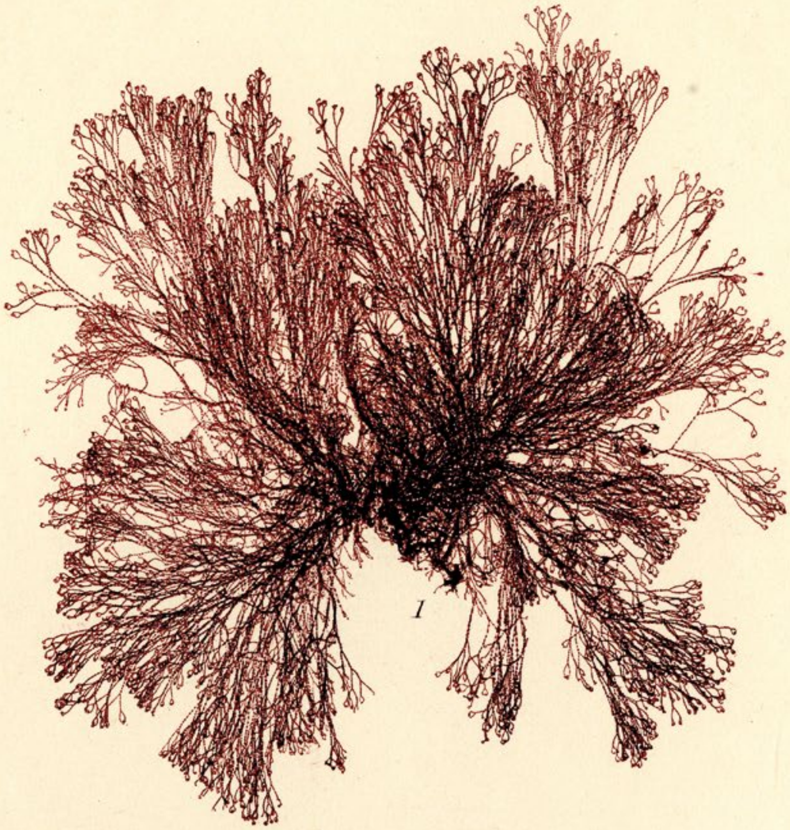
Two of the most widely circulated books produced through nature printing are Thomas Moore's *The Ferns of Great Britain and Ireland* (1855), with its 51 pages of prints, and William Grosart Johnstone and Alexander Croall's four-volume *The Nature-Printed British Sea-Weeds: A History, Accompanied by Figures and Dissections, of the Algae of the British Isles* (1859–60), with 207 pages of prints. Both volumes were nature-printed in colour

Nature print of a flame lily flower, together with pressed specimens of its leaves and a pen-and-ink sketch of its underground rhizome. This late seventeenth- or early eighteenth-century nature print was probably made by Jacob Bobart the Younger, the gardener in charge of the Oxford Physic Garden, from a specimen cultivated in Britain. The Anglo-Dutch aristocrat William Bentinck, 1st Earl of Portland, is credited with introducing the flame lily to Britain in 1690.[80]

by the British printer Henry Bradbury using an electrotyping process. In contrast to using the plant directly as a relief printing surface, here the plant is pressed between a steel plate and a lead plate, to leave an impression in the latter. The lead plate is then used to create a copper electrotype for relief printing.

Although nature printing offered the potential of a time- and labour-saving technique, it did not survive as a scientific recording tool.[81] Aesthetically pleasing nature prints are useful aides-memoires, but they hardly reach the rigour demanded of botanical illustrations or the detail achieved by photography.

Coloured nature print of the red seaweed *Ceramium echionotum*, together with line drawings showing magnified details of forceps-like branch tips and reproductive structures. The phycologist William Henry Harvey commented that members of the genus are 'very beautiful plants, and thus, in some degree, the botanist is repaid for the trouble which their investigation often occasions'.[82]



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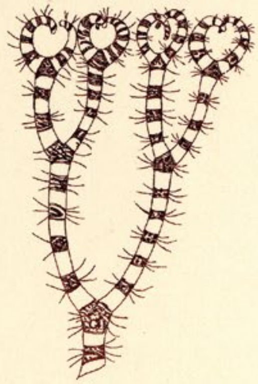

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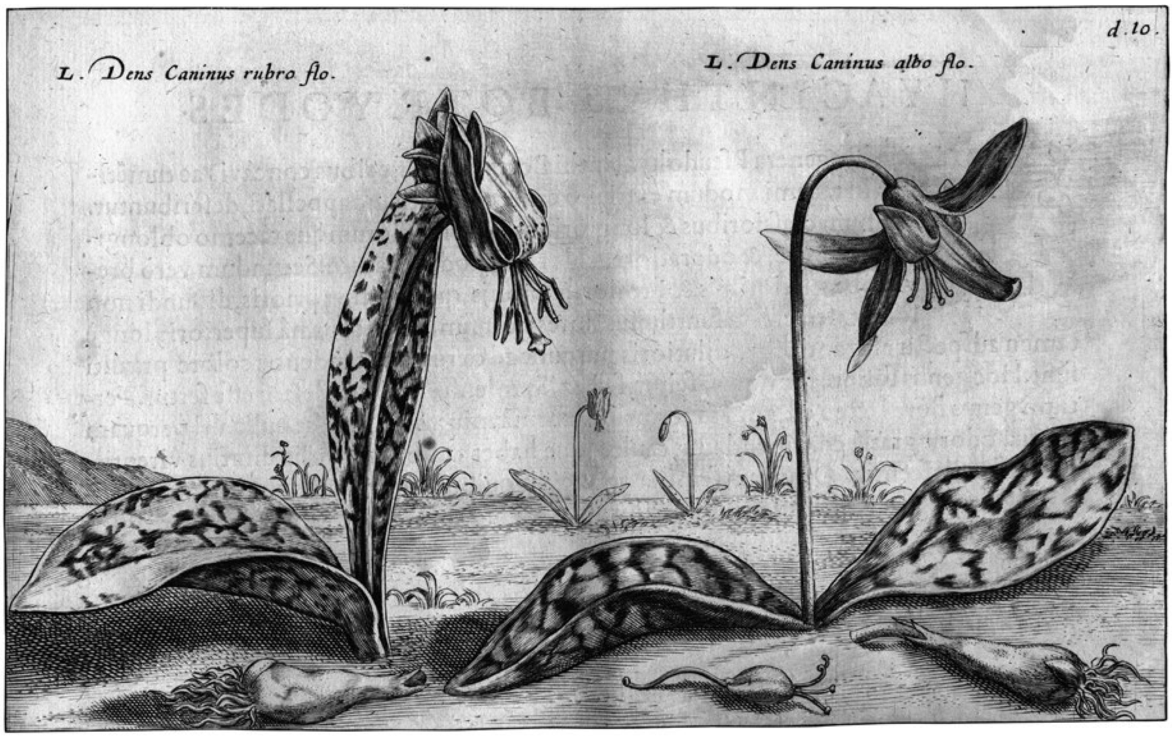
Adding colour

Much printing of botanical illustrations, whether via relief, intaglio or planographic methods, involves the reproduction of monochrome images. However, the development of cheap, rapid colour-printing techniques ensured the widespread use of polychrome images. In addition to their visual appeal, polychrome images offer authors the possibility of clarifying ideas and publishers the prospect of many sales.[83] However, publications with coloured images may be costly. Indeed, the costs associated with the preparation of woodblocks or intaglio plates were minor compared to those associated with their colouring. For example, John Sibthorp and James Edward Smith's folio-sized *Flora Graeca* (1806–40; print run 25 copies) contained 966 hand-coloured copperplate engravings; that is to say, 28,980 plates had to be hand-coloured. Each set cost about £620 to make (about 13 shillings per plate; roughly £34 in 2022), and most of that cost was associated with colouring the plates.[84]

Monochrome images could be coloured, with greater or lesser skill, by hand, or polychrome images created directly through printing processes.[85]

'Dens Caninus', the dog's-tooth violet, from Crispijn de Passe's *Hortus floridus* (Flower Garden, 1614). The engravings of *Hortus floridus*, which often show plants viewed close to ground level, proved popular, and translations from the original Latin were issued in English and French, in 1615 and 1617, respectively. The foreground comprises two bulbs and a poorly drawn fruit, while in the background the plant's habit is shown.



Hand colourists might include the book's author or purchaser, or professional artisans. One writer who coloured his own botanical work was the first Sherardian Professor of Botany at the University of Oxford, the German botanist Johann Jakob Dillenius. In 1732 he completed an eight-year-long project to describe and illustrate the rare plants in the garden of the Royal apothecary James Sherard at Eltham in Kent. The two-volume *Hortus Elthamensis* (Garden of Eltham) was issued that year with 324 pages of monochrome copperplate engravings. It was lauded by botanists, but Sherard thought the book too concerned with advancing botany rather than with praising his garden.[86] The original drawings and the copper engravings were made by Dillenius, who also hand-coloured three copies of the *Hortus*, which he left as legacies to the university and to his final physicians, Richard Frewin and William Lewis. Dillenius went on to use his skill at drawing and engraving to illustrate his most important and enduring scientific work, the *Historia muscorum* (1741), with 85 uncoloured plates of algae, mosses, liverworts and lichens.

In contrast, during the previous century the Dutch engraver Crispijn de Passe the Younger encouraged purchasers of his *Hortus floridus* (Flower Garden, 1614), 'beinge all in theire seasons the most rarest and excellentest flovvers', to colour the copperplate engravings themselves.[87] He gave detailed instructions to transform its 89 black-and-white plates so as 'to painte them even to the liffe', 'after a most exquisite manner'. If done correctly, the result would be 'the perfect trve manner of colovringe the same vvith theire natvrall colovres'. However, de Passe had no illusions about the difficulties his intended audience might experience, so he provided the necessary encouragement: 'If hethertoe (my frende) you haue,/ Performde the taske in hand:/ With ioy proceede, this last will be/ The best, when all is scande.'[88] For colouring the white dog's-tooth violet, de Passe directs his readers that the

> flower is perfect white, and shaddowed with lambesblack, hav[i]nge sometymes certaine little spotts of omber or of a very sad yellow, the laggs are rounded with sad omber, and topt with a little white vnder the omber, in the middle of those Iaggs there ariseth a manner of a clapper of a pale greene, shadowed with greene, and topt with masticote. The steale there

> of is a sad red, of lack, oker and a little greene tempered all together, shadowed with a little omber the leaves are of a cypres greene, and are marked with spotts of lack and saffron mingled together, the outtermost parte of the leaffe is somewhat sadder, and comonly throughout, they are as the spotts are that are vvithin.[89]

As with plant descriptions, had de Passe's audience never seen a living dog's-tooth violet, one can but wonder what they would have made of such instructions.

The unknown colourists working for the London-based printer James Sowerby on the plates of the *Flora Graeca* are assumed to be women whom he employed, his female relatives or relatives of the men he employed as engravers and printers.[90] Colourists had to maintain consistency between copies of the same plate, which could be determined by the availability of pigments, working conditions and individual ability.[91] Publishers reflected these challenges in their prices for monochrome and polychrome editions of the same work. For example, Plantin charged a customer ten times the monochrome price for a coloured copy of the Flemish botanist Matthias de L'Obel's illustrated herbal, the *Kruydtboeck* (Herb Book, 1581).[92]

By 1840 extensions of lithography were being used to make coloured illustrations directly.[93] Chromolithography involves making separate stones for each colour used in a botanical illustration. Each print is passed through the printing press using stones inked with different colours. The challenge of chromolithography is to keep the images aligned as they are printed on top of each other. Any slight variation in the alignment of the stones blurs the image, making an otherwise excellent botanical illustration appear fuzzy. The problem was of little consequence for botanical illustrations that were designed to be viewed from a distance in the classroom. However, for illustrations printed in books and journals, where detailed study was possible, the problem could be acute. *Curtis's Botanical Magazine*, which has been published regularly since its foundation in 1787, has an audience interested in coloured illustrations of novel plants growing in British gardens. However, scepticism on the part of generations of the magazine's editors meant that mechanical, planographic methods for colouring plates were embraced slowly. Hand-coloured copper engravings were used until

Camellia and Japanese stewartia from Homi Shirasawa's *Iconographie des essences forestières du Japon* (Illustrations of Japanese Forest Species, 1900). The chromolithograph, published in Tokyo, was based on an illustration by Nobumitsu Maruyama. The plate contrasts the external and internal features of the two species, focusing on details of flowers and fruit together with stem sections to show wood grain and microscopic structure.

1–14, STEWARTIA PSEUDOCAMELLIA, MAX. 15–30, THEA JAPONICA, NOIS.

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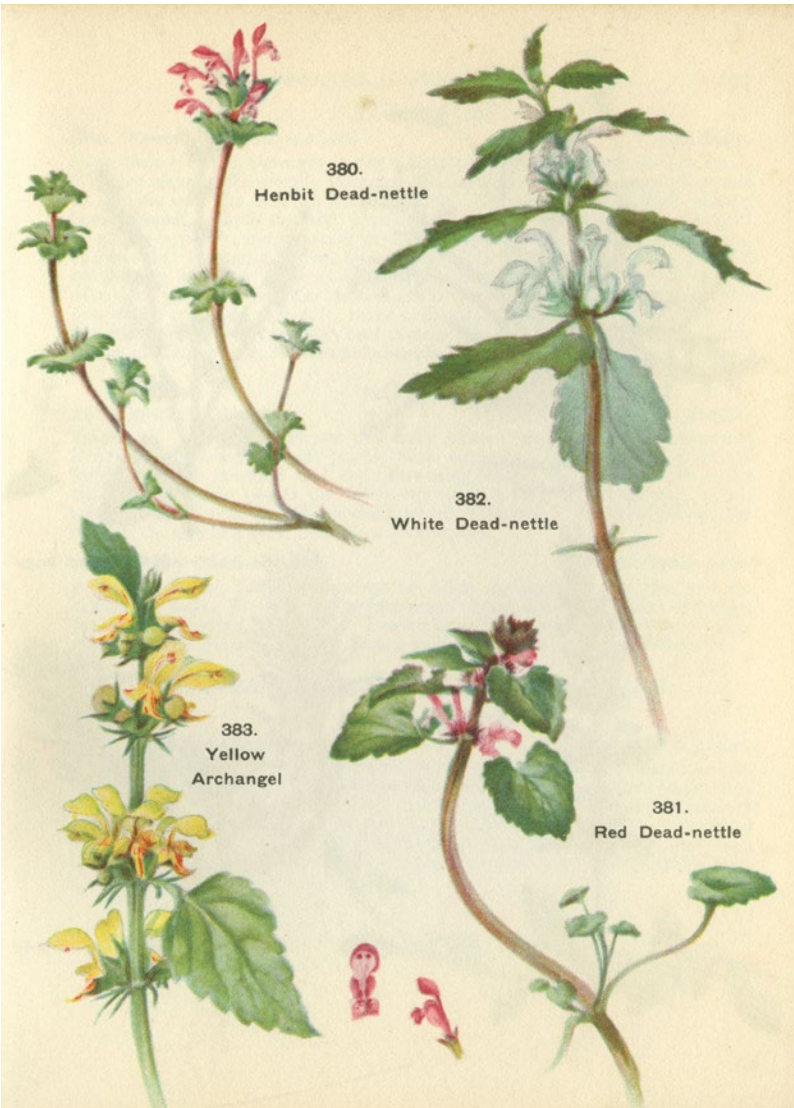


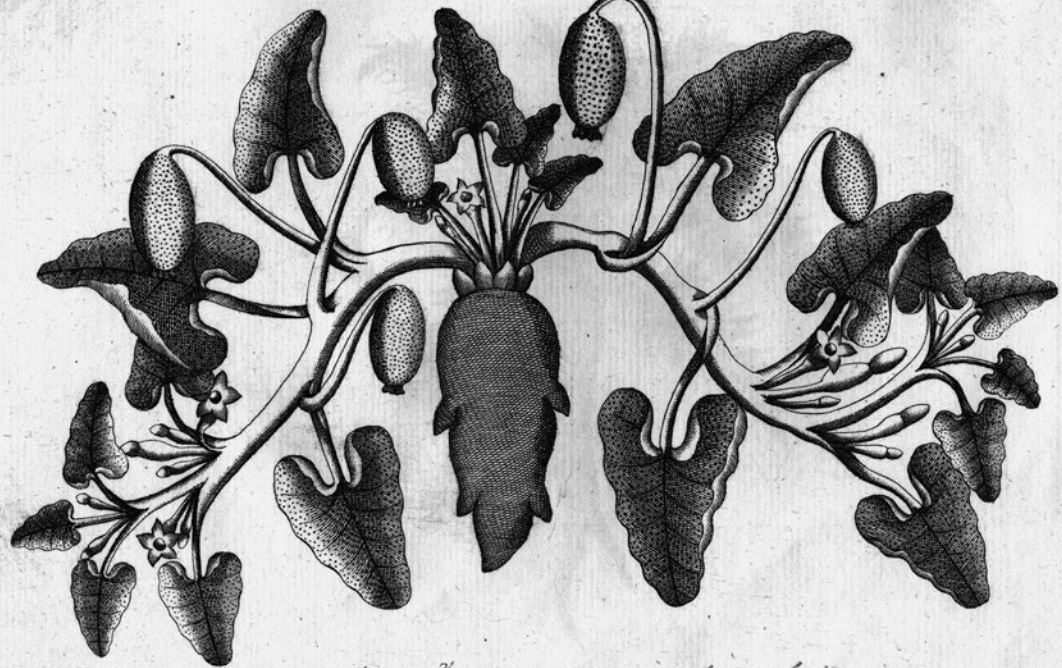
Colour offset lithograph of four members of the mint family (Lamiaceae) from MacGregor Skene's *A Flower Book for the Pocket* (1935). Most illustrations were taken from Charlotte Georgina Trower's botanical watercolours, reduced by approximately 80 per cent to fit an area that she would probably have considered 'a horrid little space'.[94]

1845, when hand-coloured lithographs were adopted; only in 1948 was the hand-colouring of the botanical plates relinquished.[95]

Colour reproduction is attractive to both audience and publisher, but may undermine the quality of an illustrator's original work through the technical limitations associated with reproduction or compromises associated with the cost of the published work. For example, in the early twentieth century original botanical watercolours by the Oxford academic Arthur Harry Church and the Hertfordshire landowner Charlotte Georgina Trower were poorly reproduced by colour-separation techniques in *Types of Floral*

Mechanisms (1908) and MacGregor Skene's *A Flower Book for the Pocket* (1935), respectively.[96] Of Trower's published work, one reviewer complained that 'the illustrations are good, but one could wish that those in colour were somewhat more definite and true to natural tints and shades.'[97] However, rather than the artist's, the failures were those of the publisher.

IN THE LATE eighteenth century scientific caution did not prevent Joseph Banks from flattering the botanical 'paper-mosaicks' of Mary Delany, friend of the powerful Margaret Bentinck, Dowager Duchess of Portland, with the observation that 'her paper representations of flowers were the only imitations of Nature he had ever seen from which he could venture to describe botanically any plant without the least fear of making a mistake.'[98] However, Dampier's potato demonstrates the value of caution when using an illustration scientifically. Specifically, illustrators must be careful when depicting their subjects, caution must be exercised when interpreting an illustrator's work, and illustrations should be complemented by physical specimens.



σίκυς ἄγριος Momordica elaterium

two

THEMES AND TRENDS

> Crateuas, Dionysius and Metrodorus adopted a most attractive method, though one which makes clear little else except the difficulty of employing it.
>
> PLINY THE ELDER, *Natural History* (*c.* 70 CE)[1]

Plants are fundamental for our food, fuel and pharmaceuticals. This statement is as true today as it was 10,000 years ago, when we began our first unconscious experiments with plant domestication. Given their central roles in our lives, it is unsurprising that plants also have decorative and symbolic importance, becoming incorporated into our mythologies and belief systems, as Yggdrasil (the Norse World Tree), for example, the Trees of Knowledge and Life in Eden, and the Bodhi Tree, under which the Buddha gained enlightenment. The mythology of ancient Greece, the cradle of modern Western science, abounds with stories of the transformation of gods, demigods and mortals into vegetables: Apollo changed his boy lover Hyacinthus; vain Narcissus was transfigured by Nemesis; and lovelorn Crocus and his lover, the nymph Smilax, were transmuted by the gods. The manners in which we have chosen to assert control over plants in many different times, places and environments contributes to our intricate modern societies.

Artists use many plant-derived products, including paper, charcoal, gums, resins, oils and even rubbers. Their paintboxes brim with plant-based pigments: blue indigo from Central American or Indian species of the pea-like genus *Indigofera*; yellow pigments extracted from European saffron, Caribbean and Central American fustic or Southeast Asian gamboge; reds from European madder, Brazilian brasil or Eurasian safflower.

Proof-copy engraving of 'sikos agrios', the wild cucumber, in flower and fruit, from Dioscorides' *De materia medica* codex in the Imperial Library in Vienna. In the 1770s Empress Maria Theresa ordered that the codex's figures be prepared for publication. Only two sets of prints exist, since the original printing plates were either destroyed or lost. Nikolaus Joseph von Jacquin gave one set to Carolus Linnaeus in Uppsala and the other to John Sibthorp in Oxford.

Even cochineal, from crushed insects, and ivory black, from burnt bones, are indirectly plant products.[2]

The Roman naturalist Pliny the Elder opined that coloured illustrations made by three botanical artists, Crateuas, Dionysius and Metrodorus, while attractive, were by no means a useful way to convey information about plants. The method was difficult, inferior to studying living plants and, of course, no substitute for writing about them. The German scholar Konrad von Megenberg's *Buch der Natur* (Book of Nature), a compendium of fourteenth-century knowledge of natural history in wide circulation across Europe, was printed in 1475 and has the distinction of being among the first printed works to include botanical illustrations that inform, rather than decorate, the text.[3] Illustrations in sixteenth-century herbals, 'plant picture-books', have been dismissed as 'a condescension to such as can not read' or to those 'incapable of mentally imaging a thing from the verbal description of it'.[4] Against his better judgement, the printer of the *New Kreuterbuch* (1539), one of a new sort of plant book to emerge in sixteenth-century Europe, acquiesced when its author, Hieronymus Bock, initially asserted that words were better than images for the study of plants.[5] The acceptance of illustrations as a means of recording data and conveying information about plants is therefore mediated by culture, place, time, opportunity and technology.

This chapter focuses on recurrent themes in botanical illustration from the roots of Western science in the Near East and the Mediterranean to the present day. Is the illustration of a specific individual plant or is it an ideal, distilling features from many individuals? Does an illustrator work solely from nature or incorporate prior knowledge, and if the latter, how much? Are illustrations for elite or popular publications? What is the interplay between illustration and text when the work is published?

Ancient worlds

Classical reliefs, friezes and papyri are replete with images of stylized plants.[6] Despite the pitfalls, the interpretation of images across millennia can contribute to our understanding of cultural relationships between people and plants. Some Egyptian images are readily attributable to plants that we know today. For example, water lilies float on the surfaces of fishponds, while

wading birds lurk among papyrus stalks. Be-sickled, slender young men bend over fields of ripe cereals. The distinctiveness of palm outlines means that even stylized images can be identified: those like dish mops are date palms, those with regularly bifurcated stems are doum palms, while those with hand-like leaves are likely to be the rare Nubian fan palm. For some images their identities become apparent only when the traces of plants known to people are excavated from their houses, middens and tombs, for example mandrake, Egyptian leek and onion. However, many images cannot now be identified with any degree of confidence. Once they may have been recognizable by the people for whom they were made; now they are little more than decorative.

Utility, beauty and symbolism are three reasons for humans to represent the natural world. Yet among the artefacts that document ancient Egyptian culture, there are images that emphasize other motives for depicting plants: power and ownership; revelation and communication; and religion and state.

In granite and limestone, pharaonic dynasties exhibited their authority in the temples, chapels, walls, obelisks and pylons at Karnak, the religious complex on the eastern bank of the Nile at Luxor. On the opposite bank, beneath a cliff at Deir el-Bahari, a funerary temple was begun in the Eleventh Dynasty. A complex of royal temples eventually proliferated, including those of the pharaoh Hatshepsut and her stepson and nephew Thutmose III.[7] At these sites, which are among the most popular tourist attractions in Egypt today, Hatshepsut and Thutmose ensured that events in their respective reigns were set in stone.

In 1495 BCE Hatshepsut funded a trading expedition, commanded by the court official Nehsi, to the land of Punt (probably in the Horn of Africa or in Yemen).[8] In friezes on the walls of Hatshepsut's mortuary temple at Deir el-Bahari, the permanent, final report of the earliest recorded government-funded plant-collection expedition was presented. Punt's green gold – living trees, rooted in baskets suspended from poles, for planting in the Precinct of Amun-Re at Karnak – were bartered and traded for Egyptian products. The academic consensus is that the trees loaded on to Hatshepsut's treasure ships were either frankincense or myrrh. Botanical imagery has been used to document successful collecting and trading expeditions ever since.

In contrast, Thutmose's Levantine campaigns were about territory more than trade. Their botanical and zoological spoils are recorded in bas-relief on the walls of the so-called Botanical Garden at Karnak, an enclosed area that may have been used during initiation rituals associated with the sun god Amun. Today, this *hortus petrus* is exposed to the elements.[9] A few of the plant images, such as those of members of the iris and arum families, are identifiable, but most are too stylized to be matched with living plants. Because the species would have been unfamiliar, Egyptian artists, constrained by their own stylistic conventions, probably worked from living plants, sketches or descriptions, rather than from memory. The 'Garden' fulfils one function of a modern botanic garden: it shows off plant diversity to reflect the prestige of its owner.

Images from these tombs and sanctuaries tell us nothing about the biology of the plants portrayed – that was not their purpose. However, some Egyptian images, together with those on Babylonian and Assyrian bas-reliefs and seal stones, show that ancient civilizations understood the practical importance of plant biology, especially sexuality, albeit entwined with religious allegory.[10]

The date palm – a productive, rich staple of storable protein and carbohydrate for desert peoples – naturally drew especial attention. The palm, probably first domesticated in Mesopotamia, is the Babylonian and Assyrian Tree of Life. Its early domesticators gradually learned that it was particularly fruitful when grown with its leaves in the furnace of desert heat and its roots submerged in cool, wet mud.[11] Moreover, these peoples discovered that there were two sorts, female and male, both necessary for fruit production, but only one bearing fruit. Mesopotamians also discovered how to propagate date palms from cuttings, creating orchards of the two sorts. Importantly, the discovery of the mechanics of hand pollination meant that only a few male palms were needed to ensure reliable date harvests, leading to the establishment of detailed palm pollination laws and the development of a commercial market in male palm flowers.

In the late nineteenth century the English anthropologist and founder of cultural anthropology Edward Burnett Tylor drew attention to Assyrian bas-reliefs, such as those in the palace of King Ashurnasirpal II at Nimrud, in present-day Iraq, where winged figures present cone-like structures to palm-like trees.[12] Tylor interpreted the structures as bunches of male flowers

of the date palm, a controversial idea not completely dismissed by scholars of Mesopotamian cultures.[13] It is a tantalizing prospect that ancient Near Eastern images may have depicted plants as sexual organisms, whose reproduction could be manipulated by people, since such ideas were rejected by Western plant sciences until the early eighteenth century.[14]

The best surviving evidence of a 'scientific', rather than 'decorative', approach to the representation of plants from the classical world are the collections of illustrations associated with copies of Dioscorides' text of *De materia medica*.[15] Some 383 illustrations are part of a manuscript known as the *Codex Anicia Juliana* (*c.* 512 CE), a reference to the Byzantine princess Anicia Juliana – its first owner – or the *Codex Vindobonensis med. gr. 1*, named after the place – the Imperial Library in Vienna – where, more than a thousand years after being made, it finally came to rest. Another manuscript, *Codex neapolitanus*, with 406 images dating from the late sixth or early seventh century CE, became part of the Biblioteca Nazionale, Naples, in 1923. In both, some of the illustrations are highly naturalistic, while others are stylized, raising questions about the relationship between illustrations and text, whether more than one artist was involved in producing the illustrations, and whether those illustrations were copied from earlier sources or made from living plants. Of greater or lesser completeness and originality than the *Codex Anicia Juliana*, later Greek and Latin botanical manuscripts are known. Together, the images and text of these manuscripts were copied and recopied over nearly 1,500 years in Western European medical and botanical literature.[16]

Literary and visual copying erodes both the quality of the data and the information contained in documents. By the early sixteenth century generations of copying had rendered all but the most familiar plants unrecognizable in manuscripts and printed books. The illustrations in such herbals were of little value as reference sources for communicating cures for ailments, identifying unknown medicinal plants or even maintaining the standards that ensured apothecaries dispensed what physicians prescribed.

Portrait or epitome

The appearances of plants differ among and within species. Consequently, since the earliest days of plant depiction, illustrators have been faced with

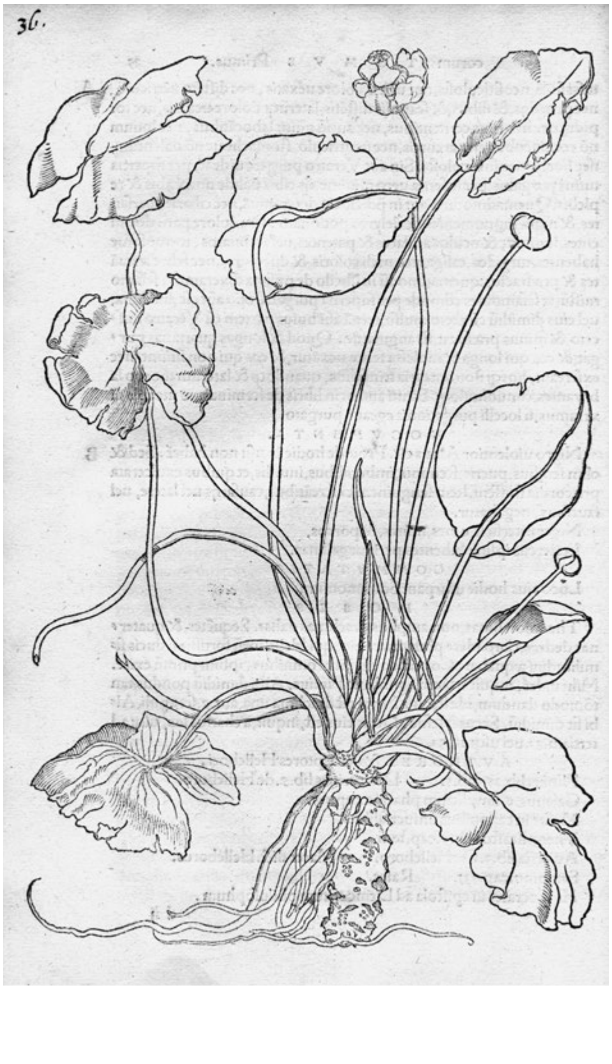
choices and compromises. Choices mean deciding which individual or stage of a plant's life to represent. Compromises come with deciding whether to create an epitome from individuals to highlight key features, or to make the portrait of a specific individual that includes the blights and ravages of growth, age and handling. Outside horticulture, botanists generally emphasized the distinctions between species rather than variation within species. Consequently, during the eighteenth and nineteenth centuries botanical illustrations as epitomes became the norm – the so-called typological approach.

In 1530 the Strasbourg printer Johann Schott combined botanical letterpress, by the German theologian Otto Brunfels, with eighty woodcuts, which were based primarily on the work of the German artist Hans Weiditz the Younger, into the *Herbarum vivae eicones* (Life-Like Plant Pictures).[17] A second volume appeared in 1531, and a third volume, following Brunfels's death, in 1536. Brunfels wanted to revive ancient knowledge about plants by filleting, editing and critically examining reliable classical authorities against his modern knowledge gleaned from local people who lived and worked with plants.[18] As a Lutheran theologian during the Reformation in Europe, his publications fell foul of the Vatican, and all his works, including the *Herbarum vivae eicones*, were banned. The *Index librorum prohibitorum* (Index of Prohibited Books) is an unexpected place to catalogue sixteenth-century books that transformed the scientific portrayal of plants.[19]

Weiditz and his team, their work 'never wantonly sacrificed to mere scientific accuracy', used everyday plants to produce remarkable images that capture precisely what they saw in front of them – flaws and all.[20] Based on watercolours, woodcut prints were made from vivid, naturalistic portraits of individual plants. A white dead nettle pulled up from the ground, with the soil washed from its roots, was laid before the artist to paint precisely as seen. Drying fibrous roots adhere to one another, while the flowers, with their fused, hooded petals and star-like calyx, nestle in rings among leaves that are starting to wilt. The pasque flower is a stunning portrait of an individual plant ripped up roots and all. Delicate hairs cover the stems and wilting leaves, while one bud is bursting, an open flower has a crumpled petal, and fruit is beginning to mature.[21]

Weiditz appears to have worked independently of Brunfels. The ordering of the text reflects the publisher Schott's schedule, rather than Brunfels's

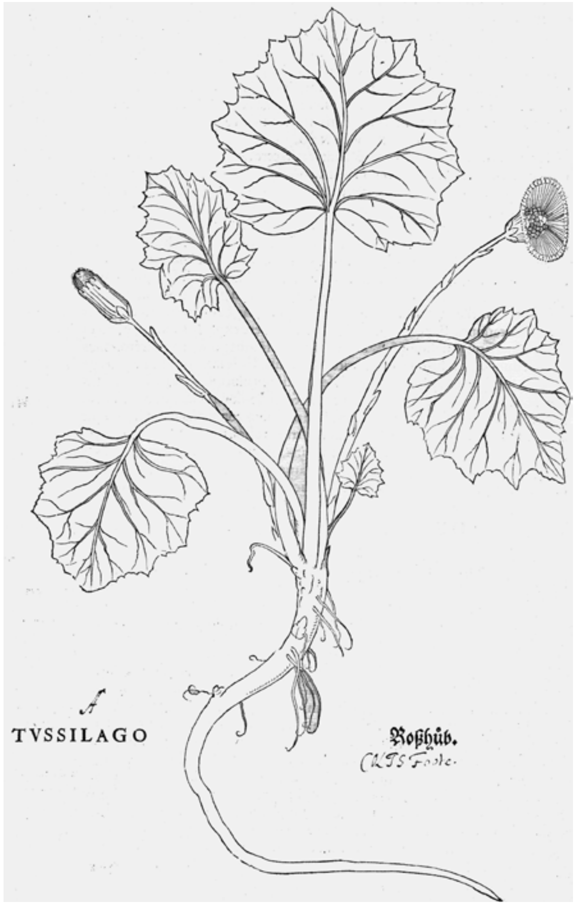
desire, but that schedule itself was at the mercy of the skill of Weiditz's masters and journeymen working on the woodcuts.[22] Most of Brunfels's plants are life-size, but some had to be resized in order to accommodate them to their woodblocks. The yellow water lily was uprooted whole from its aquatic habitat, then – with its substantial rhizome and roots, broken and twisted leaves, and battered flower – arranged on a table for drawing. Whether resizing occurred at this stage or at the woodcutting stage is unknown. In groundsel, carefully observed flower heads, in various stages of development, contrast with the plant's odd, stunted appearance. The reason becomes obvious when the model watercolour is examined: the woodcutter shortened the stems between the leaves so that the illustration would fit the woodblock.[23]



Naturalistic woodcut of yellow water lily from Otto Brunfels's *Herbarum vivae eicones* (1530). The portrait shows an individual plant, as it would appear after having been cleaned of mud, with young, unfolding leaves and tatty older ones, together with flowers at three stages of development. Other than turning over two leaves so that the lower surfaces can be seen, few attempts were made to arrange the plant aesthetically.

A decade after the publication of Brunfels's German translation of the *Herbarum vivae eicones*, the *Contrafayt Kreüterbůch* (1532), the German physician Leonard Fuchs published *De historia stirpium commentarii insignes* (Remarkable Commentaries in the History of Plants) in Latin in 1542 and a year later in German.[24] Rather than focusing on portraits of specific plants, Fuchs's artisans used the typological approach to produce 511 folio-sized black-and-white line woodcuts rooted in the direct observation of nature.[25] As an academic in the German university city of Tübingen, Fuchs was instrumental in introducing medical students to the practical observation of plants, in his own words to 'convey their living aspects, and not, as many have done until now, leave the knowledge of medicinal plants to the apothecaries, those uneducated men, and stupid little women.'[26]

One of these medicinal plants was coltsfoot, with its reputation for the relief of coughs, respiratory conditions and even St Anthony's Fire (ergotism).[27] Weiditz's woodcut of coltsfoot depicts a wilted, leafy shoot harvested in the

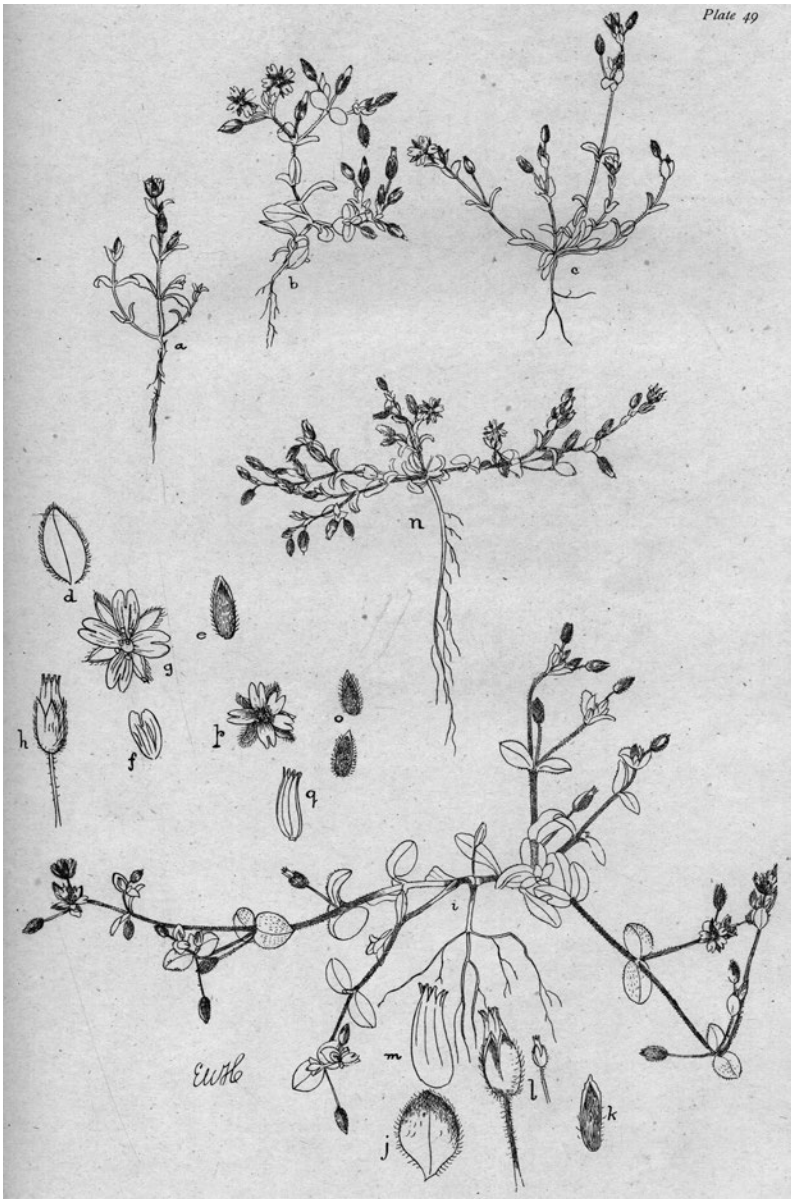


Two naturalistic sixteenth-century woodcuts of coltsfoot. Hans Weiditz's illustration from Otto Brunfels's *Herbarum vivae eicones* (1530; left) is a portrait of a leafy summer shoot. In contrast, the artists who illustrated Leonard Fuchs's *De historia stirpium commentarii insignes* (1542; right) appear to have copied Brunfels and, incongruously, added two flowering heads, creating a typological illustration.

summer.[28] In contrast, Fuchs's artists present a similar-looking, more standardized image with the addition of two drooping flower heads.[29] In nature, coltsfoot's flower heads and leaves would never be seen together; the image is an attempt to create a single image of a plant at different times in its life cycle. Another example of a composite image is Fuchs's hemp, where male and female flowers are represented on the same plant, rather than on separate plants as in nature.[30] A more ambiguous case is 'Taubnessel' (dead nettle), with its three flowering shoots arising from a single root, which Fuchs reports as having white, yellow or purple flowers.[31] However, in uncoloured copies of *De historia stirpium*, reliable identification is impossible; the shapes of the flowers and leaves are too similar, and only when coloured can inferences be made.[32]

Insights from people who are both first-rate botanists and exceptional botanical illustrators are particularly valuable when evaluating

botanical illustrations. Arthur Harry Church was forthright about those who criticized figures in Brunfels and Fuchs, dismissing them as 'people who have not the slightest idea of what [the illustrations] were intended for, or how they were done. These men did not set out to make pretty pictures or artistic sketches.'[33] A striking feature of the illustrations in both Brunfels and Fuchs is the inclusion of roots, a feature that disappeared from many Western botanical illustrations. This was probably because, during



Individual portraits of sea mouse-ear plants collected from different parts of the British Isles and illustrated in *The Cambridge British Flora* (1920). This annual chickweed is widely distributed in coastal areas of western Europe. Edward Walter Hunnybun, the illustrator, who specialized in making scientific portraits of living plants, captures subtle differences in habit, branching pattern, and leaf, flower and fruit form.

the eighteenth century, classification systems such as those of Carolus Linnaeus recognized floral features as being particularly important.

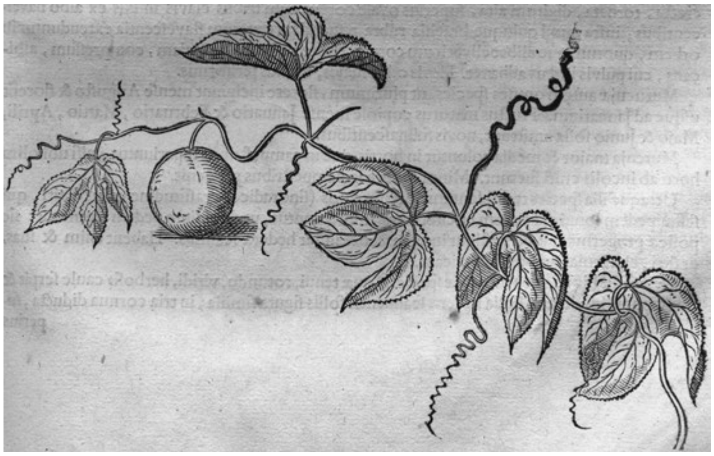
Although it was the norm in botanical illustration by the twentieth century, the typological approach was resisted by some illustrators. Edward Walter Hunnybun, a solicitor-turned-botanical illustrator, was responsible for the 397 black-and-white illustrations used as plates in the published volumes of Charles Edward Moss's ill-fated *The Cambridge British Flora* (1914, 1920).[34] Hunnybun

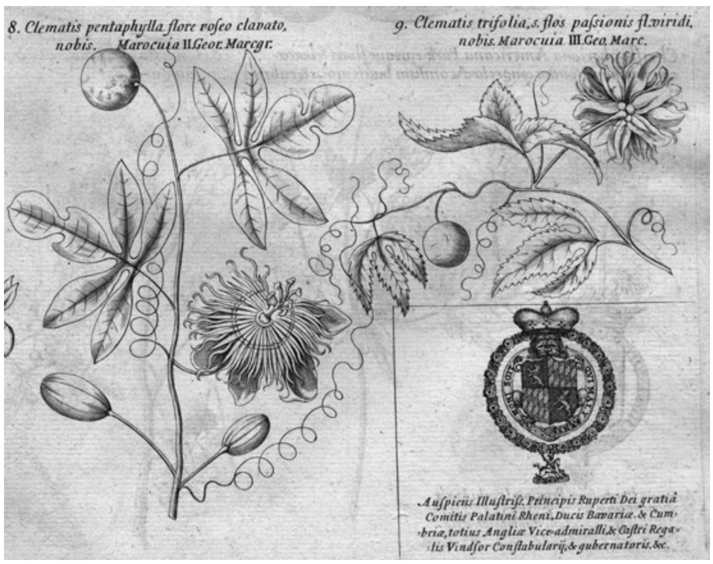
> had a natural genius for accurate line drawing which developed with practice until it became an easy matter for him to transfer the sweeping lines of the living plant directly to paper. The natural result was a singularly accurate picture of each specimen, free from such errors as arise either from mingling the characters of different plants or from adding imagined features to dried specimens. Herbarium material he steadily refused to use: his purpose was the portrayal of actual living individual plants . . . portraiture to a single specimen resulted in a corresponding gain of that permanent truth of observation which was to him the first requirement.[35]

However, his refusal to engage with typological species representation may have contributed to the failure of the entire *Flora* project.[36]

To copy or not to copy

Botanical illustrators rarely ignore published images. Moreover, since illustrations are expensive to create, authors and publishers may prefer to recycle existing images rather than create original work. Consequently, a viewer confronts the problems of whether, how and why an illustrator uses their predecessors' work. In Fuchs's *De historia stirpium* of 1542, the typological woodcut of wake robin, which, with its distinctive cowl enclosing a spike of tiny flowers, cannot be confused with any other northern European plant, shows an etiolated, late-spring individual and summer fruit. Separate detail has also been added to Fuchs's woodcut: a cowl broken apart at the base to show the flowers. Stylistically, this is like Brunfels's image, which may have been the model for Fuchs's woodcut.[37]



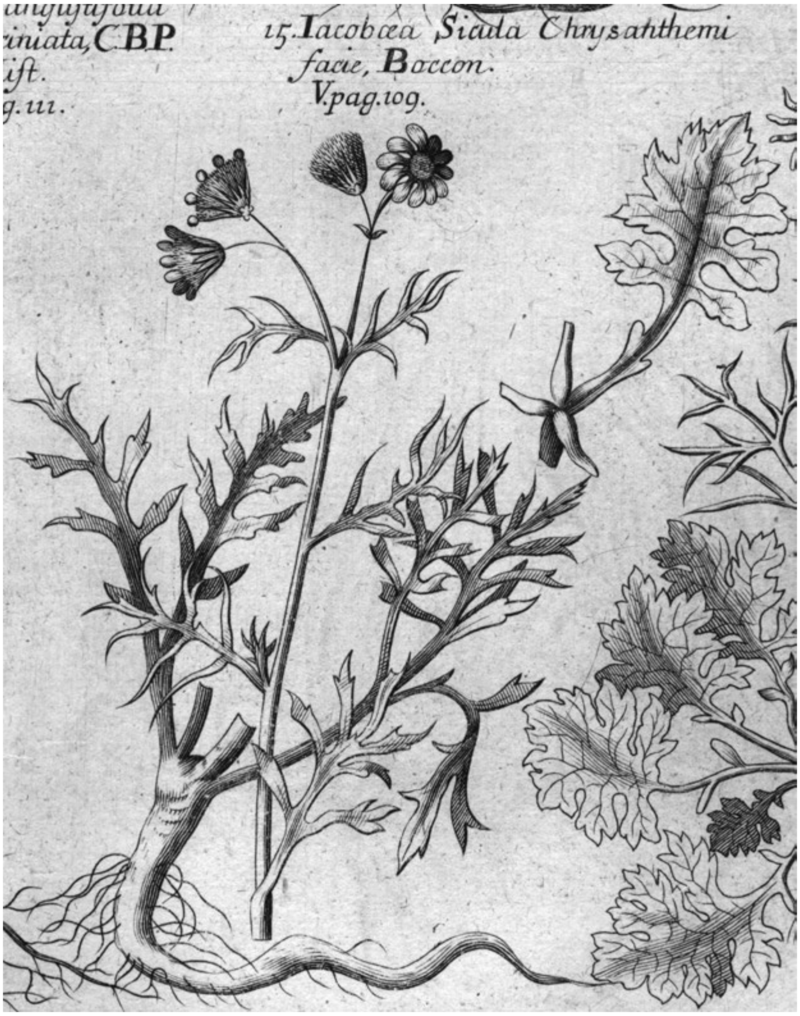


Two sorts of passion flower depicted in a copperplate engraving from Robert Morison's catalogue of the world's plants, *Plantarum historiae universalis oxoniensis* (1680; bottom), by an unknown artist. The stems, leaves, buds and fruit were copied from woodcuts in Willem Piso and Georg Markgraf's *Historia naturalis brasiliae* (1648; top right and centre), while the flowers appear to have been taken from a woodcut in John Gerard's *The Herball* (1633; top left).

Rather than directly copying entire images or parts of images from single sources, illustrators may create images by selecting parts from several sources. For example, two neotropical passion flowers engraved into copper by an unknown artist contributing to Robert Morison's *Plantarum historiae universalis oxoniensis* (Oxford's Universal History of Plants, 1680) are chimaeras. The leaves and fruit were copied from woodcuts in Willem Piso's *Historia naturalis brasiliae* (Natural History of Brazil, 1648), while the flowers come from John Gerard's *The Herball* (1633).

If images are used as scientific evidence, then the relationships among original and copies must be understood. For example, twentieth-century

Copperplate engraving of the ragwort 'Iacobaea Sicula Chrysanthemi facie' from Robert Morison's *Plantarum historiae universalis oxoniensis* (1699; left), showing how an illustrator has simplified a model taken from Paolo Boccone's *Icones & descriptiones rariorum plantarum Siciliae, Melitae, Galliae, & Italiae* (1674; right). The resulting illustrations cannot be objectively identified, and are scientifically valueless, despite formerly being used to fix the introduction date of Oxford ragwort to Britain. Both illustrations were made by unknown artists and engravers.



arguments about the British introduction of Oxford ragwort from Sicily, and the evolutionary consequences of the plant's spread, rest on the interpretation of a copperplate engraving in Morison's *Plantarum historiae* of 1699.[38] However, this image was copied from Paolo Boccone's *Icones & descriptiones rariorum plantarum Siciliae, Melitae, Galliae & Italiae* (Images and Descriptions of Rare Plants from Sicily, Malta, France and Italy, 1674). Boccone's illustration, apparently made from a badly pressed plant specimen, was simplified by Morison's engraver to create an image with little resemblance to any known European ragwort.

Illustrations in the Latin and German folio editions of Fuchs's *De historia stirpium* proved both popular and influential as they contributed

Of cockoupynt.

Cockoupyn.

the roote is whyte as dragones is, the whyche, beynge soden, is eate: because it is not so bytynge, as it was before.

The vertues.

The roote, sede, and leues of aron, haue the same propertie that dragon hath. The roote is layd vnto ẏ gowtye membres, with cowdunge: and it is laid vp & kept as dragones rootes are: and because the rootes are gentler, they are desyred of many to be eaten in those countreis, wheras the rootes of coccowpynt are not so bytynge hote, as they are in England and in Germany. Dioscorides semeth by hys wryting, to shew, that where as he was borne, Arõ, was not so sharpe, as it is with vs. Galene also writeth, that aron is hote in the fyrst degre, & drye in ẏ same. But it that growth with vs is hote in ẏ thyrd degre at the leste. Wherfore some peraduenture wyll say, that thys our aron is not it, that Dioscorides & Galene wrote of. But Galene in these wordes folowyng: which are wrytté in ẏ second boke, *de elementorum facultatibus*: wytnesseth, ẏ ther are. 2. sortes of arõ: one gẽtle, & another, biting. *In quibusdam regionibus acrior, quo dammodo prouenit, ut prope ad dracontij radicem accedat. &c.* In certayne regyons after a maner, it groweth more bytyng, and sharpe: in so much, that it is allmost as hote, as dragon is: and that the fyrst water must be casten out, and the roote soden agayne in the second. Thys herbe growynge in Cyrene, is dyfferyng frõ it, of our countre. for it that is wyth vs in Asia for a great parte, is sharper then it, that groweth in Cyrene.

Of Mugwurt.

Mugwurt is called both of the Grecians, and latines, artemisia: of the duche, byfus, or bifoit. The true artemisia, is as lytle knowen nowe adayes, as is ẏ true pontyke wormwode: & lesse, as I thynke. for this great mugwurt is suche an artemisia, as our wormwood is absinthiũ ponticum: that is bastard, and not the true herbe. Dioscorides wryteth: ẏ artemisia, for the most parte

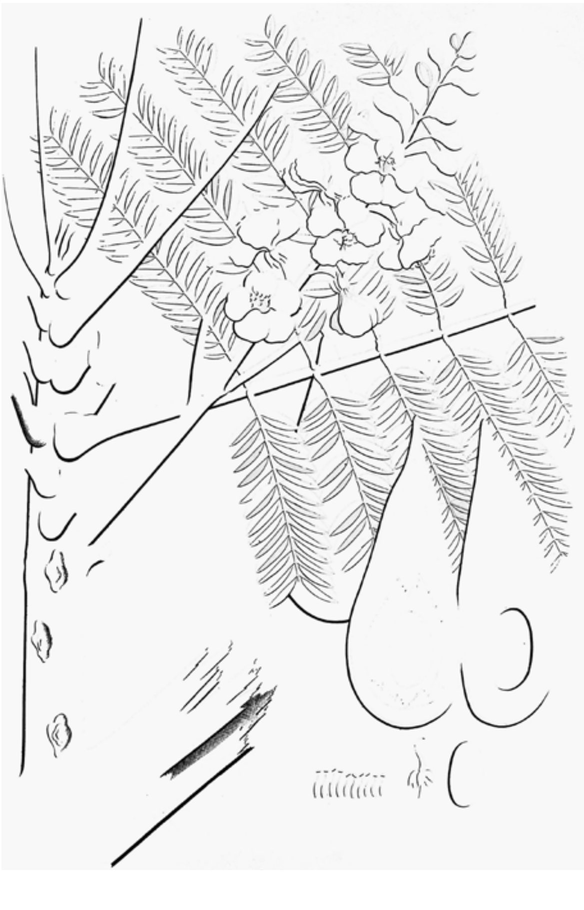
C.i. gro-

Comparison of three woodcuts of wake robin. Hans Weiditz's illustration from Otto Brunfels's *Herbarum vivae eicones* (1530; left) is a portrait of an individual plant in late spring. The artists who illustrated Leonard Fuchs's *De historia stirpium commentarii insignes* (1542; centre) stylized key features of the species' habit, leaves and flowering structure, adding a typological fruiting structure. The artists also added a naturalistic representation of the flowering structure ripped apart to show the distinct whorls of female, male and sterile flowers, although they did not appreciate the significance of these observations. Fuchs's woodcut was copied and reduced for publication within a page of text in William Turner's *A New Herball* (1551; right). Note that Turner's image is reversed relative to that of Fuchs, which is often a good indicator of image copying.

to the ebb and flow of botanical imagery among sixteenth-century European printing houses.[39] Woodcuts, reduced in size for three editions published in 1545, were circulated. The Swiss printer Michael Isingrin sold the woodblocks to the Parisian printer Jacques Gazeau for a French edition of 1549. Two years later, in London, the blocks were used by the exiled Dutch printer Steven Mierdman to print William Turner's *A New Herball* (1551). In Antwerp, a selection of the blocks were used in Dutch editions of Rembert Dodoens's *Crŭÿde boeck* (Herb Book, 1554, 1563) and Charles de l'Écluse's French translation of Dodoens's work in 1557. Once again in London, the blocks were printed in Henry Lyte's English translation of Dodoens's *A Nievve Herball* (1578).

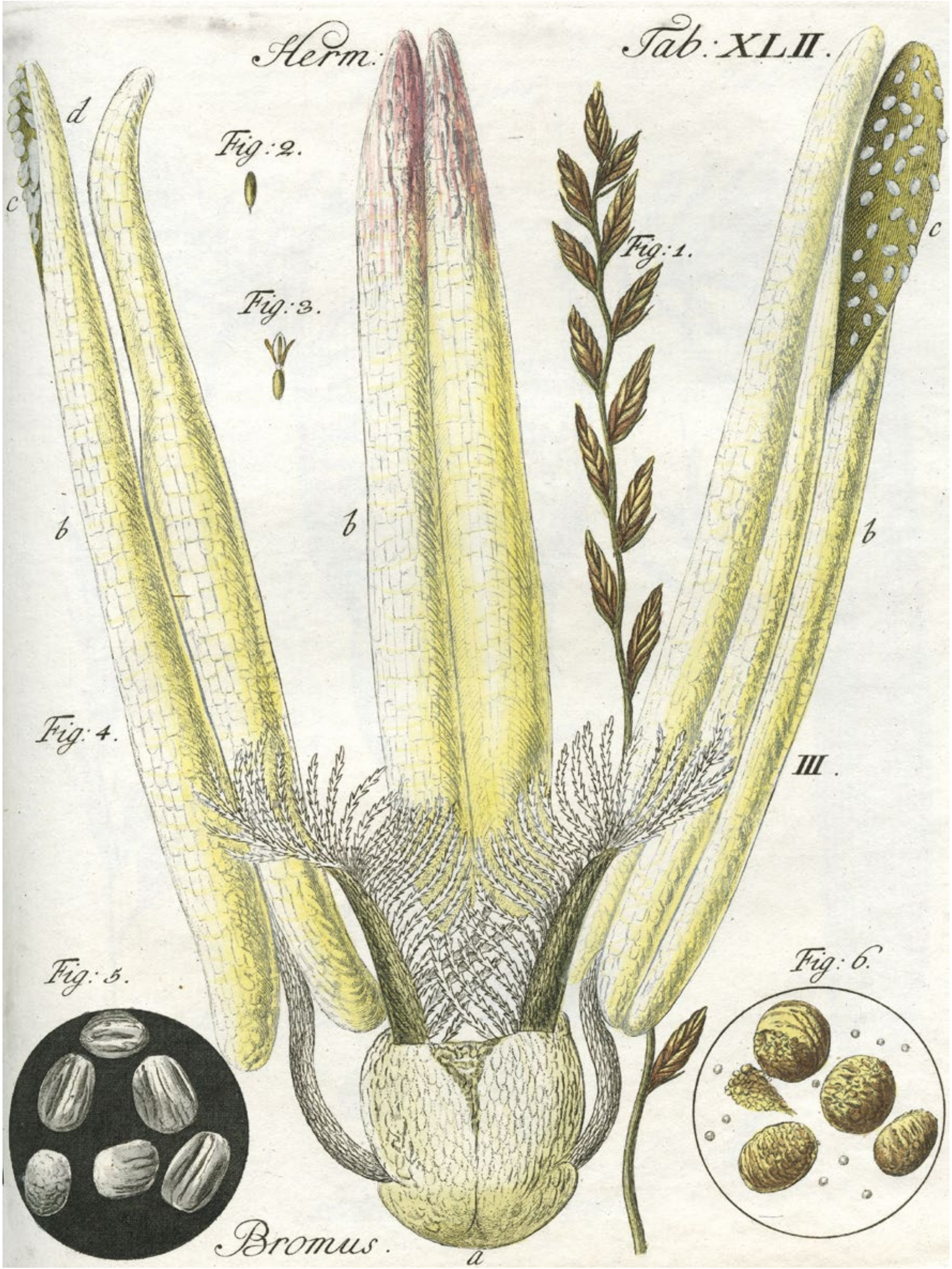
Although reduction, recutting and reprinting may erode the quality of the images, large-format images do not guarantee a high level of detail. The copperplates used to print the illustrations in Basil Besler's *Hortus Eystettensis* (Garden of Eichstätt, 1613), which 'requires a wheel-barrow to take it about', are large enough to accommodate the head of an annual sunflower at natural size.[40] Yet the illustrator chose to include little more detail than was shown in Fuchs's work six decades earlier. In the early nineteenth century, thirteen years after the death of the Brazilian botanist José Mariano de Conceição Vellozo, imperial whim and nationalistic fervour trapped

Lithograph of the fast-growing leguminous tree *Schizolobium parahyba* from José Mariano de Conçeição Vellozo's *Flora Fluminensis* (1827). The species' natural distribution extends from southern Mexico to southern Brazil, where among the uses made of its soft, light wood is boat construction, hence one of its Brazilian common names, *guapuruvu* (canoe wood). Vellozo's illustrations, lithographed by Alois Senefelder in Paris, often appear as flat outlines with limited added surface features, together with selections of magnified detail. Furthermore, inconsistent use of line thickness to indicate shadow and light direction creates confusion in the illustration.



the Brazilian emperor, Dom Pedro I. After seeing the German botanist Carl Friedrich Philipp von Martius's work on Brazilian plants, the emperor apparently asked: 'must foreigners come in order to describe our plants; cannot we do this ourselves?'[41] Vellozo's unpublished work, including more than 1,600 large-format black-and-white illustrations of the plants around Rio de Janeiro, the *Flora Fluminensis* (Flora of Rio de Janeiro) (1825–7, 1831), was 'rediscovered' and ordered to be lithographed in Paris.[42] As costs waxed, interest waned. After the abdication of Dom Pedro, bills were no longer paid, so printers sold many of the lithographs as wastepaper; some were even used for gun cartridges during the French invasion of Algeria in 1830.[43] Martius was scathing about the *Flora Fluminensis*, describing it as a 'monstrous example of an ill-advised and overambitious literary enterprise', while William Jackson Hooker considered the work a 'magnificent abortion'.[44]

Church complained in 1919 that 'ideas of Herbals are founded on the poor borrowed illustrations of Gerard and Parkinson.'[45] The problem has not gone away. Copying and editing illustrations is easier today than ever before. When an illustrator acts as an editor, whether through making decisions about living or dried plants, or copying the work of others, the viewer must be aware of the type and extent of such editing.[46] Remaking an illustration or changing its format risks compromising its scientific value, perhaps introducing or propagating misconceptions – problems that illustrations in Dioscorides' *De materia medica* suffered with over the course of 1,500 years.[47] More cynically, such illustrations are in danger of being dismissed as merely decorative. In the mid-1990s exquisite, scientifically accurate pen-and-ink illustrations of fir and spruce species from the taxonomic work of the Dutch botanist-illustrator Aljos Farjon, together with substantial parts of the associated text, were plagiarized to produce a 'hack-job' in which the 'artist' was unable even to copy the originals correctly.[48]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Scale and magnification

Our familiarity with the habits and behaviour of common mammals and birds often makes identifying poor illustrations of them straightforward. Proportions may be wrong or stances unnatural, making the animal appear to have suffered at the hands of an indifferent taxidermist or to be cobbled together from second-hand reports. However, perhaps because we may not observe them as closely as we do animals, the individual differences of plants are often overlooked. Linnaeus was emphatic that, if botanical illustrations are to look natural and be of scientific value, 'all parts should be recorded in their natural position and size.'[49] Consequently, accurate measurements are essential for making scientific botanical illustrations.

Before Hans Weiditz's work for Brunfels, many published botanical woodcuts appear cartoon-like, focusing on plant form, leaf shape and the general appearance of flowers, and paying little attention to size, proportion or scale. However, specific structures that attract attention for the documentation, differentiation and classification of plants – and their applied uses – make the representation of detail essential. Consequently, illustrations often include separate, magnified details of parts, such as hairs, or fruit with its associated seeds. Given botanists' devotion to reproductive structures, it is natural that illustrators should dissect and lay out floral details. Flowers are split and magnified to show the number and relative arrangement of the different parts, complemented by separate, detailed drawings of such parts as the sepals, petals, stamens and pistils.

Greatly magnified flower of perennial ryegrass showing three yellow anthers beginning to release pollen, two comb-like styles, and two straw-coloured lodicules surrounding the ovary. Images marked 'Fig. 1' to 'Fig. 3', at natural size, show how the tiny flowers are surrounded by tough scales and packed into the flower spike. Inside the circles are dry (left) and wet (right) magnified pollen grains. Hand-coloured engraving from Wilhelm Friedrich von Gleichen-Rußwurm's *Auserlesene mikroskopische Entdeckungen* (Exquisite Microscopic Discoveries, 1777).

Illustrators may choose to use limited magnification of a small range of structures. For example, Ferdinand Bauer focused on flowers or floral parts, arranging low-magnification watercolours in a row below the principal, natural-sized subject of his watercolours. However, illustrators may choose to incorporate many magnified structures into the composition of a plate, using forms of dissections to direct the viewer's attention around the image. Magnification also introduces complexity when illustrations are reproduced or copied. Although scale bars are essential, they may detract from a plate's aesthetic, while degrees of magnification in a legend may be overlooked during reproduction. Consequently, for illustrators to use magnification effectively, they must be aware of how their work will be published and reproduced.


A.
B.
C.
D.
D.
D.

Lithograph of four African species of the woody genus *Combretum* recognized by the German botanists Heinrich Gustav Adolf Engler and Friedrich Ludwig Emil Diels in their detailed taxonomic account published in 1899. The plate was lithographed by the Polish botanical illustrator Joseph Pohl, who collaborated with Engler for more than four decades. Details on this plate have helped modern botanists to realize that only two species are in fact illustrated (one is labelled A and the other B, C and D).

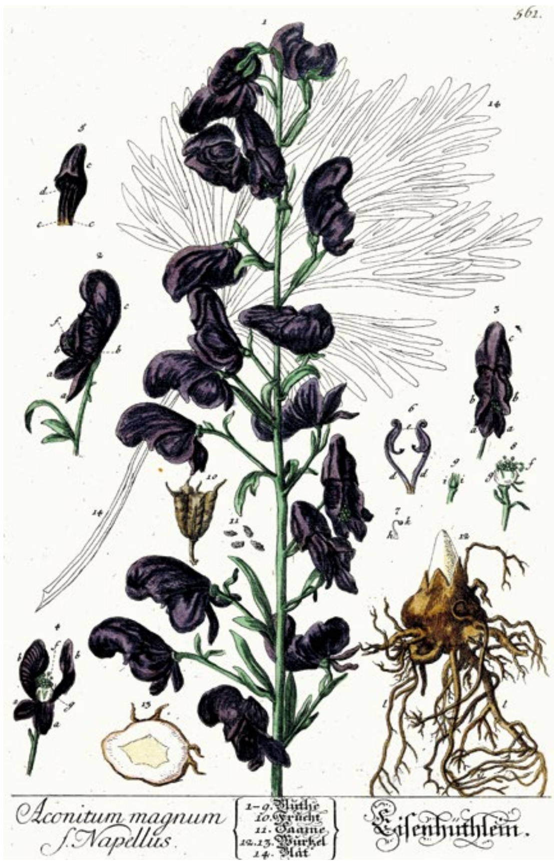
Following years of practical field experience, the English artist-naturalist Mark Catesby documented the natural history of the southern part of the Thirteen Colonies in his *Natural History of Carolina, Florida and the Bahama Islands* (1729–47).[50] Catesby's distinctive hand-coloured engravings, many of which combine plants and animals, are among the most recognizable natural-history images from colonial America. One of these plates, showing an American bison rubbing itself against the broken trunk of a rose locust tree, vividly demonstrates a familiar challenge: scale.[51] With no other information, the reader is forced to create their own scale, but by constructing an integrated scene, Catesby creates visual dissonance. With the bison as an internal scale the flowers appear huge, but when

Hand-coloured engraving of an American bison, 'a perfect likeness of this awful creature', and a flowering rose-locust tree from Mark Catesby's *Natural History of Carolina, Florida and the Bahama Islands* (1771 edn). In the field, Catesby 'never saw any of these trees but at one place near the Apalatchian mountains where Buffelos had left their dung'.[52] Catesby's composition of the plate creates cognitive dissonance in the viewer through the confusion of scale. Moreover, he confuses the structure of the plant through his positioning of the flowers as emerging from a leaf, despite his claim that the model was a living plant rather than a dried specimen.

the flowers are used as the scale, the bison becomes minuscule. Either way, the trunk seems incapable of sustaining the attentions of the bison or supporting the flowering shoot. Consequently, if botanical illustrations are to have scientific value, scale and proportion must be obvious.

Economy of space

Scientific botanical illustration is an activity associated with elites that have abundant wealth, leisure and interest. Illustrations therefore reflect the periods and places in which they are made. In the eighteenth century, when some of the world's most recognizable botanical illustrations were created, illustrators' choices also hint at the political backdrops of European capitals jostling for global economic and cultural hegemony.[53] Illustrations are expensive additions to scientific publications, but dichotomies that pit text against image are too simplistic.[54] Today, reviewers of scientific papers are often asked to consider whether figures 'add value' through enabling readers to judge for themselves the scientific conclusions drawn by authors. That is, there is implicit recognition of the synergy between image and text.



Images are powerful, yet words and experience of plants in their natural habitats may be necessary to present the range of a species' variation. Nearly five hundred years ago Fuchs recognized these subtleties when presenting botanical information to physicians. He even criticized the publishers of Brunfels's *Herbarum vivae eicones* and Theodor Dorsten's *Botanicon* (1540) for using illustrations in the service of Mammon rather than scholarship.[55] Authors, illustrators and publishers have the challenge of summarizing experience, guiding their readers in order to maximize meaning, especially when misconceptions may have lethal consequences.

The Italian physician Pietro Andrea Mattioli, a more accomplished botanist than either Brunfels or Fuchs, wanted to reconcile specific plants referred

to in Dioscorides' *De materia medica* with botanical discoveries made in sixteenth-century Europe, Asia and the Americas. His *Commentarii in sex libros Pedacii Dioscoridis* (1544) was published first in Italian, with later editions in Latin, French, German and Czech. Between the first and final – 45th – editions, which were published two hundred years apart, tens of thousands of copies were sold.[56] Early editions were illustrated with approximately five hundred small woodcuts. Later sixteenth-century editions, which included large woodcuts by the Italian Giorgio Liberale and the German Wolfgang Meyerpeck, contained more than 1,200 illustrations.[57]

As a student in the early 1520s, Mattioli witnessed condemned prisoners being used to test the lethality of aconitine, a poison found in the roots of blue-flowered monkshood, which was illustrated with care in his *Commentarii*. Different *Aconitum* species contain different concentrations of aconitine, and giving the wrong species at the wrong dose could

Hand-coloured metal engravings by the German illustrator and engraver Nikolaus Friedrich Eisenberger of three *Aconitum* species (opposite, left, right: monkshood; yellow monkshood; northern wolfsbane) added to the German-Latin edition of Elizabeth Blackwell's *A Curious Herbal*, called *Herbarium Blackwellianum* (1750–73). *Aconitum* species were not included among the five hundred plates for the original English edition, made between 1737 and 1739. In Central Europe, research by Anton von Störck brought the medicinal potential of this highly toxic genus to the attention of physicians.

prove fatal.[58] More than two hundred years later the Viennese physician Anton von Störck, who undertook pioneering clinical trials to investigate the medicinal uses of toxic plants, described the medicinal efficacy of sublethal doses of aconitine on humans. In his text, Störck refers to the cream-flowered northern wolfsbane, but the accompanying illustration, drawn and etched by a medical student called Augustin Cipps, is of monkshood – a different species.[59]

Botanical illustrators unconfined by the economics of publication may enjoy the generosity of space when illustrating their subjects. They may choose large formats, placing their subject on a page surrounded by sufficient space to show it off. However, for images that are to be published, illustrators may have to engage in the algebra of spatial economy. The illustrator accepts the challenge of presenting the maximum amount of data in the smallest possible space with the greatest possible visual appeal. The illustrator becomes more than an eye and a hand to capture an image. Instead, they are essential in the process of data capture, and information storage and transmission.

Devices adopted by Fuchs and Mattioli to summarize variation within species, and to account for seasonal variation and interspecific differences, may be interpreted as space-saving devices. However, such devices may be confusing, especially when the viewer is insufficiently aware that they are being used. Present-day equivalents of these devices attempt to ensure that viewers are guided through illustrations – the visual equivalent of a well-written piece of music or prose.

Publish or be buried

If hard-won botanical data and inferences are to become part of scientific discourse, they must be circulated and open to criticism. A refrain that is familiar to modern botanists is 'publish or perish', as institutions try to demonstrate their societal relevance while competing in the marketplace of public and private funding. Publication and the individual rewards it may bring are not modern concerns. In the eighteenth and nineteenth centuries, as they jostled with their rivals for reputation and career, both John Sibthorp and Joseph Hooker worried that collecting plants detracted from writing about them.[60] Some botanists, such as the Scotsman Robert

Wight, who spent his professional career in southern India, saw publication as a public service, but believed that

> to compare this work [Wight's *Icones plantarum Indiae Orientalis*, 1840–53], commenced and prosecuted under such adverse circumstances, uncheered by public approbation, and so slenderly supported that hitherto it has been conducted at a very considerable loss, with the luxurious and costly Lithographic botanical works of Europe would indeed be doing it an injustice.[61]

Publications, and hence reputations, are enhanced by the right illustrator, making the right illustrations of the right subjects. Yet bringing botanical illustrations, made in the field or studio, into the public domain is technically and financially challenging, and consequently many remain unpublished. Botanists or illustrators may lack funds or the inclination to publish, or their plans may be overtaken by events. Unless illustrations are communicated through publication, the vast efforts of their creators to circulate scientific data and communicate scientific ideas may be lost, or at least delayed. Illustrations that remain unstudied in private collections, or 'lost' in archives, do not become part of scientific discourse, and the data they contain 'dies' or remains in a state of 'suspended animation'.

Academic botanists tend to publish technical monographs, Floras and papers in scientific journals, often with strict conventions about the presentation of botanical illustrations. With the Victorian and Edwardian popularization of science, the demand for botanical illustrations in identification guides, horticultural trade magazines and flower books expanded. Yet printing technology, with its need to balance quality and price, risks rendering otherwise exceptional botanical illustrations unexceptional.

By the end of the eighteenth century, Portugal's income from Brazil was waning as profits from the sugar boom disappeared and diamond and gold mines became exhausted. Portugal needed to discover new ways to exploit her three-hundred-year-old colony. The Portugal-based Italian naturalist Domenico Vandelli, therefore, with the backing of the Portuguese queen Maria I, planned a grand expedition to explore the economic potential of central and northern Brazil. The Brazilian-born, Portuguese-educated

naturalist Alexandre Rodrigues Ferreira was chosen to lead this poorly funded enterprise. His only companions were two draughtsmen (José Joaquim Freire and Joaquim José Codina) and a gardener (Agostinho Joaquim do Cabo).[62] The expedition, known as the *Viagem philosophica* (Philosophical Journey), was the most important natural-history expedition undertaken in colonial Brazil.[63]

In 1783 Ferreira arrived in Belém, at the mouth of the Amazon River, where he spent twelve months. The following year he travelled up the Amazon, visiting the Rio Negro, the Rio Branco and the northwestern border of Brazil. The team moved up the Rio Madeira in 1788, and by 1790 had arrived in Cuiabá in the state of Mato Grosso; they finally returned to Belém in 1792. During their nine years away from the city, Ferreira and his tiny team travelled thousands of kilometres through landscapes and habitats unknown to the Portuguese. As they travelled, they collected botanical, zoological, mineralogical and anthropological specimens, and made thousands of natural-history sketches.

The collections were dutifully dispatched to Lisbon, but a decade had dramatically changed the political situation. The ageing queen was feeble-minded, and Europe was negotiating the upheaval of the French Revolution. The Iberian Peninsula was eventually brought into wider European internecine conflicts, and in 1808 the Portuguese court fled to Brazil, under the leadership of the Regent João (later João VI). The specimens, notes and drawings from the *Viagem philosophica* gathered dust in archives in Lisbon and Rio de Janeiro, unstudied and unappreciated, for nearly a century.[64] The novel research of Ferreira and his team effectively did not exist for practising natural historians; their discovery of species unknown in Europe was not associated with their efforts, despite their exertions having cost the life of do Cabo.

Magnificent publication

As Ferreira explored northern South America for the Portuguese monarchy, the academic John Sibthorp and illustrator Ferdinand Bauer explored the western fringes of the Ottoman empire, at the political and biological interface between Europe and Asia.[65] Sibthorp's reasons for exploring the eastern Mediterranean were personal: he wanted an intellectual legacy.

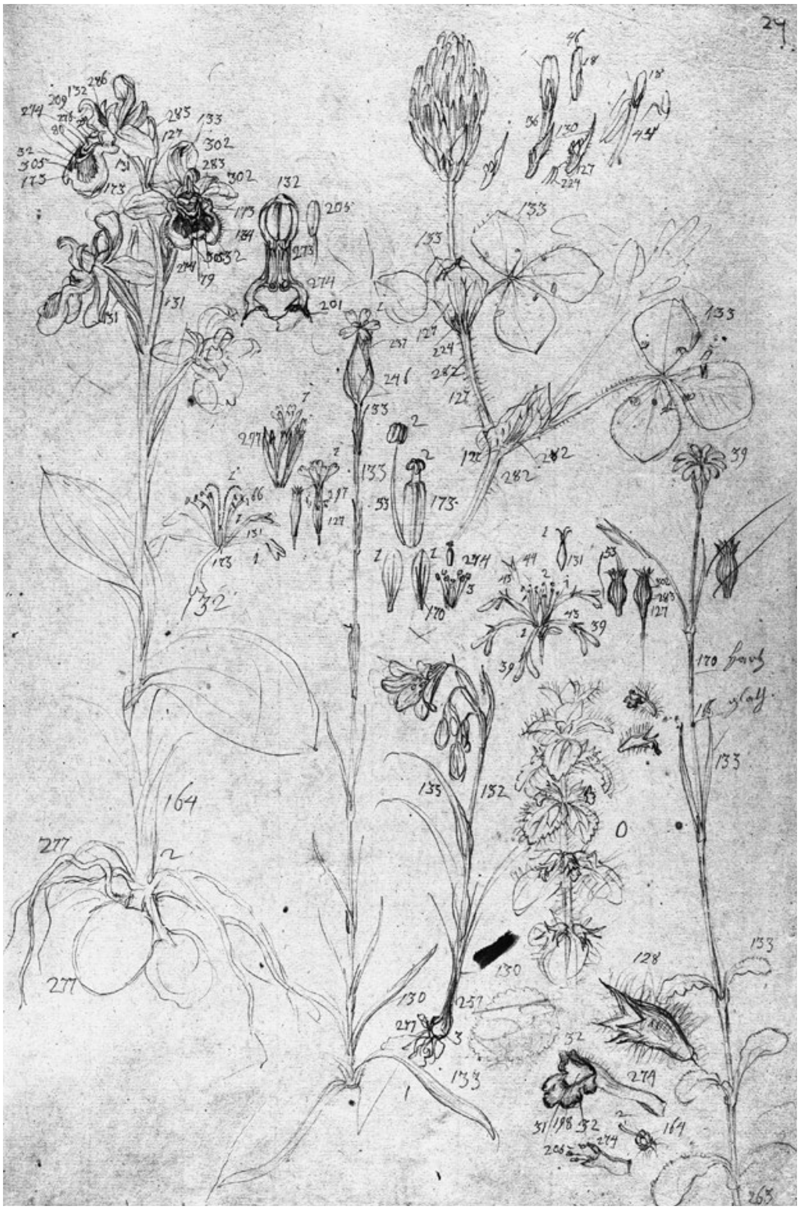
It was a mercenary calculation that included botanical exploration and illustration of a poorly known region: 'my Painter [Bauer] has drawn several which, I hope some future Day will do me as much Credit as those of [Claude] Aubriet have done [Joseph Pitton de] Tournefort.'[66]

During 1786 and 1787 Sibthorp and Bauer travelled in northern Italy, the Apennines, Sicily, Crete, the Aegean islands, Cyprus, the Dardanelles, western Turkey and Greece. Sibthorp collected plants and made notes, but committed the bulk of his observations to memory. Bauer made botanical sketches in pencil, recording plant colours in clouds of numbers. When they returned to England, he began transforming his sketches into watercolours, which were completed by 1792.

Sibthorp – who, 'with all his talents . . . had little forsight of danger or difficulty and was always inconsiderate of his health' – died in 1796.[67] After two expeditions to the eastern Mediterranean (1786–7 and 1794–5), he left a chaotic legacy of Bauer's watercolours, unlabelled herbarium specimens, and manuscripts and field notes in his execrable handwriting. One of his travelling companions, John Hawkins, tried to excuse Sibthorp's dilatory habits: 'I am sorry to find you [James Edward Smith] so ambarrassed about the habitats as well as the Identity even of the species, which results from the hasty manner in which a Traveller thro' Greece necessarily records his observations.'[68] However, in his will, Sibthorp funded and left explicit instructions for the completion of the *Flora Graeca*, an account of plants in the eastern Mediterranean, which became one of the most lavish and expensive Floras ever written.

The burden of the enterprise fell to Sibthorp's friend James Edward Smith, whose most enduring work is his contribution to James Sowerby's *English Botany* (1791–1813), which, in 36 octavo volumes and across 2,592 plates, catalogued all known British plants. The *Flora Graeca* enterprise became a collaboration between men with complementary skills and personalities who worked to the limits of their abilities. Rents and income from one of Sibthorp's estates contributed to the cost, so that only the very best was acceptable to his surviving executors, Hawkins and Thomas Platt, who spent 44 years fulfilling their friend's wishes. Smith was the project's intellectual backbone, while James Sowerby had the expertise to do justice to Bauer's work by engraving and colouring exceptional, high-quality botanical plates.

Smith was faced with conditions imposed by Sibthorp's will, the obligation to rely on fragmentary materials, and the discovery that Sibthorp had feet of clay. Sibthorp stipulated that all Bauer's watercolours must be engraved, printed and coloured at actual size to the highest standard.[69] Smith began the enterprise with the laborious construction of the unillustrated, four-part *Flora Graeca Prodromus* (1806–13), in which references were made to Bauer's illustrations, but those were in Smith's hands and



Field sketch (left) of the sawfly orchid made by Ferdinand Bauer during his journey with John Sibthorp through the eastern Mediterranean in 1786 and 1787. In the field Sibthorp used a system of numbers to denote colours. When he arrived in Britain he used his field sketches to produce life-size watercolours (right).

therefore unavailable for critical examination by other botanists. The first fifty hand-coloured plates of the 966-plate *Flora Graeca* (1806–40) were published in the same year. Economic necessity meant that fascicles of fifty plates were published erratically over 34 years, because 'the expense was so large [that] it was necessary to have some return from one Volume while another was publishing, otherwise the subscribers must have waited a much longer time, and have paid much more at one Time than they would be willing to pay.'[70]

The task of producing impressions of Bauer's watercolours was immense, with nearly 29,000 individual folios having to be printed and hand-coloured. Watercolours were transferred from Smith's home in Norwich to Sowerby's workshop in London, where copies were prepared. Those copies were then checked by Smith against the originals, and engraved in copper before a proof print was made. The proof print was coloured and returned to Smith together with the original watercolours for colour checking. Once this master print was returned to London, corrections were made and the scientific name and plate number added. The final stage was to make impressions from the plate and to colour them according to the coloured master print. This method ensured that both the outline and the colouring of Bauer's watercolours were rendered with extraordinary accuracy.

Initially, Sibthorp's executors hoped for fifty subscribers, but finally only 25 could be found. Optimism 'that later volumes would be cheaper and the last perhaps would come out for little or nothing' was misplaced.[71] The rarity and cost of the *Flora* meant that most copies were in the hands of a few wealthy, private collectors. Copies were available in the universities of Oxford and Cambridge, but the British Museum had only Joseph Banks's partial copy. Trustees of the Museum even took the managers of the *Flora Graeca* project to court, arguing that as a copyright library the Museum was entitled to a free copy.[72] In 1828, after much detailed legal argument, the court agreed with the managers: that 'a part of a work, to which there were twenty-six subscribers, and which only thirty copies were printed, – published at intervals of several years, at an expense exceeding the sum to be obtained by the price of the copies, and which expense was defrayed by testamentary donation, was not holden to be a book demandable by the British Museum'.[73] In the early 1840s the Italian botanist Michele Tenore had to travel from Naples to Paris to study a copy in the private library of

Hand-coloured copperplate engraving (left) of the Mediterranean tanner's sumac made in James Sowerby's workshop and published in the third volume of John Sibthorp and James Edward Smith's *Flora Graeca* (1821). The plate was based on a watercolour (right) Ferdinand Bauer made in Oxford between 1788 and 1793, using field sketches he had drawn between 1786 and 1787.

the French banker and naturalist Jules Paul Benjamin Delessert – 'the gift of the world's most magnificent Flora.'[74]

When Sibthorp visited the Biblioteca Vaticana in 1786, he had complained that 'to see even a printed book it is necessary to have the permission of a Cardinal – this Gene [inconvenience] to study renders the library a useless name.'[75] Ironically, he imposed a *gêne* of his own making on his research and Bauer's illustrations. His estate sponsored one of the world's rarest, most magnificent and inaccessible Floras, ensuring that its use was restricted to privileged elites.[76] The *Flora Graeca* became a masterpiece of published botanical illustration – a work of art – rather than a work of science.

Through programmes of digitization, some of the world's great libraries and archives are making available vast collections of botanical images. Images that were once available only to the wealthy, or involved people crossing continents to study them in private libraries, can be searched and explored by anyone on their own terms, although the text – often in Latin – remains inaccessible to many. The original illustrators could never have conceived of their work being so readily available. For example, during the twenty-first

century it is likely that more people have seen Bauer's work for the *Flora Graeca* than saw it during the previous two centuries.

Changing fortunes

Botanical illustrations and familiar artworks are mediated through the technology of reproduction. It is likely that most people who recognize Leonardo da Vinci's *Mona Lisa* (1503–19), Johannes Vermeer's *Girl with a Pearl Earring* (*c.* 1665) or Gustav Klimt's *The Kiss* (1907–8) have seen chemical or digital photographs rather than the original works. Church was acerbic in his assessment of the state of early twentieth-century British botanical illustration:

> the admiration and respect of posterity is [*sic*] earned only by those who utilize to the utmost the resources of their age: and nothing is worth doing which is not of the very best. If the British Flora of the future, passing beyond the horizon of hand-coloured copper-plates, as in [William] Curtis and [James] Sowerby of a hundred years ago, is to come back to cheap process line-blocks, these should be entrusted to those who not only have received an adequate art-training of their generation, and really know something of floral botany, but who have an instinctive appreciation of the bewildering manifestations of plant-life, and can utilize an artistic training without falling into absurd mannerisms or slip-shod ways.[77]

During the nineteenth century developments in photography offered the prospect of an effective alternative to botanical illustration for the rapid creation of precise, naturalistic botanical images. The English photographic pioneer Henry Fox Talbot used plants as objects for experimenting with techniques, exploring means of creating precise images of their forms, especially such isolated parts as leaves.[78] However, photographic equipment was cumbersome and expensive, the techniques difficult to master and the methods for photographic reproduction poor, compared to those of traditional botanical illustrators. During the twentieth century photographic plates gave way to film, cameras became easier to use, and the quality of

lenses improved. Today, with access to a mobile phone it is possible to produce photographs whose quality exceeds that of the very best film cameras made two generations ago. However, technology is no guarantee of the quality or value of a photograph – just as high-quality pigments do not make a high-quality botanical illustration.

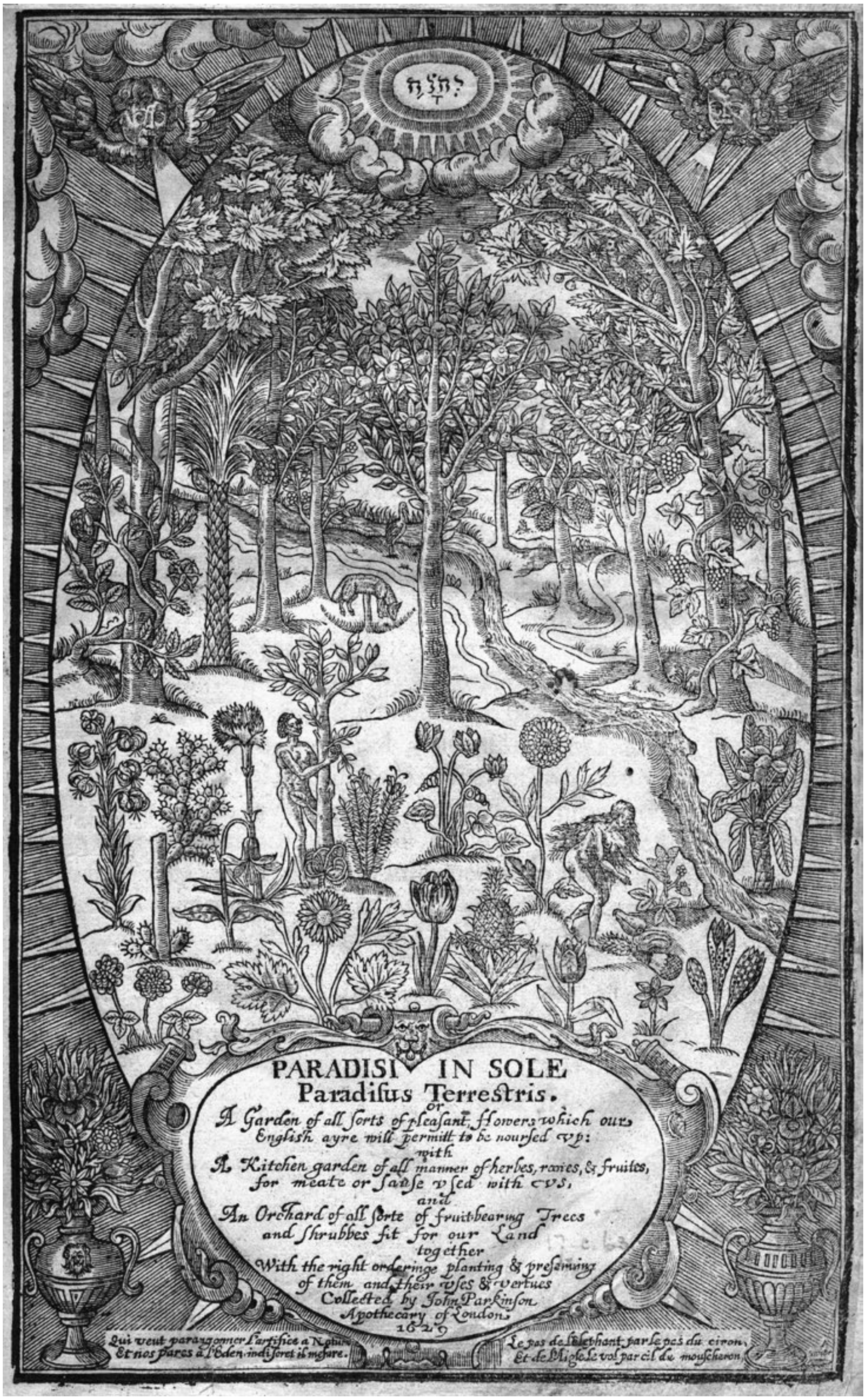
Digital photography has become the means of creating exact, immediate, visual records of botanical objects, whether in the field, laboratory or library. Yet the methods adopted by botanical illustrators remain the approach of choice in areas of botanical research. The traditional reasons for choosing a botanical illustrator to depict a plant include the ability to be selective as to the parts of the subject emphasized, the omission and/or substitution of damaged parts, and the composition of numerous stages of the life cycle into a single plate. Moreover, colours can be matched precisely, scales adjusted and enlargements made to emphasize detail. Less tangibly, choices and compromises made by botanical illustrators in composing an illustration are clear, but with post-production processing of digital photographs such editing is frequently not obvious. However, rather than competing, scientific photography and botanical illustration are synergistic, the advantages of each approach revealing complementary information about a plant. A good botanical illustration, like a good photograph, is evidence that complements and clarifies text – perhaps even making science visually attractive, and its results more widely understood and appreciated.

Accurate illustrations matter because we have powerful, immediate – sometimes visceral – reactions to visual stimuli. An illustrator aims to capture primary data that may lead to information, which eventually becomes botanical knowledge. Some illustrations depict plants so that they can be readily identified, while others are comparative, showing differences and similarities among species. Botanical illustrations, whatever their purpose, emphasize the cultural nature of science. They are points of transition, where the illustrator is the filter between a living organism and what we think we know about that organism. However, one must guard against illustrations that, becoming so primped and pimped, are little more than practices to deceive, and useless as scientific evidence.

Illustrations must be treated with the same degree of scepticism that one reserves for written and spoken words – a task that is made more difficult with visually stunning images. Consequently, to interpret a printed

illustration it is necessary to have context and to trust the integrity of the collaborations that produced it.

AS PART OF the scientific process, illustrations are evaluated critically for their accuracy, technical competence and perhaps aesthetic appeal. Faced with a printed botanical illustration, a critical observer must satisfy themselves about six broad questions. What is being illustrated? Why was the illustration made? How were the illustration and the printed image produced? When was the illustration made and the observations recorded? Where was the image made and whence did the model come? Who was the illustrator and who transformed the illustrations for printing?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PARADISI IN SOLE
Paradisus Terrestris.
or
A Garden of all sorts of pleasant flowers which our
English ayre will permitt to be noursed vp:
with
A Kitchen garden of all manner of herbes, rootes, & fruites,
for meate or sause vsed with vs,
and
An Orchard of all sorte of fruitbearing Trees
and shrubbes fit for our Land
together
With the right orderinge planting & preseruing
of them and their vses & vertues
Collected by John Parkinson
Apothecary of London
1629
Qui veut parangonner l'artifice a Nature,
Et nos Pares à l'Eden indiscret il mesure.
Le pas de l'elephant par le pas du ciron,
Et de l'Aigle le vol par cil du moucheron,

three

SCIENCE AND ILLUSTRATION

> Look at the backside of a Nettle-Leaf, and you shall see it all full of Needles, or rather long sharp transparent Pikes, and every Needle hath a Crystal pummel, so that it looks like a Sword Cutler's Shop, full of glittering drawn Swords, Tucks, and Daggers.
>
> HENRY POWER, *Experimental Philosophy* (1664)[1]

The history of science is littered with ideas that were held to be true until dismissed in the light of new evidence. Despite scientists being used to the shifting intellectual sands upon which they build their knowledge, new data may not kill old beliefs. Mandrake myths temper popular understanding of plants, while dustheaps of ancient plant uses are regularly sifted for keys to longevity and beauty (plant users are, after all, human). Botanical illustrators work within such contexts, since they may make the first records that lead to scientific discoveries and the development of new ideas.

Western European scientific botanical investigation began with the writings of Theophrastus, the so-called father of botany, where the emphasis was on medicine and agriculture. The study of plants rapidly became allied to, and in some cases synonymous with, medicine, while Christian tradition taught that plants were God-given, immutable and 'pure'.[2] Studies of botany in Renaissance Europe focused on the naming and ordering of useful plants – a task delegated by God to Adam (Genesis 2:19). In the early eighteenth century, with experimental proof that plants were sexual organisms and as vast numbers of unfamiliar plants were being brought to European shores from voyages of exploration, trade and colonization, old

The east and west winds (Perpetual Spring) are represented in the upper corners in Christopher Switzer's title-page woodcut for John Parkinson's *Paradisi in sole* (1629). In the lower corners, vases are filled with cultivated flowers familiar in seventeenth-century England. The plants (which include carnation, lily, tulip and cyclamen) are not depicted to scale. To the right of Eve, on the far bank of the river, is 'Musa Serapionis' or 'Adams Apple tree', which is copied from John Gerard's *Herball* (1597), and is thought to be a banana. Within this garden paradise, Lilliputian figures of Adam and Eve are seen grafting a tree and gathering strawberries, respectively. To the top right of Adam is the mythological vegetable lamb or barometz.

beliefs gradually changed, especially during the European Enlightenment. This eighteenth-century cultural and intellectual movement with rationality and reason at its heart has been characterized as the 'Age of Reason', when literate, prosperous men and some women of specific classes dared themselves to know.[3]

Gradually, intellectual developments arising from the Enlightenment rendered plant description and classification no longer the primary objective of botany. Fundamental questions started to be asked about how plants grow, feed and reproduce: 'even the so-called useless plants may have their allotted service to man; and though not offering any material uses, may be made available for other and higher purposes. They can perform a share of the great work of enlightening the mind, and refining the taste, and purifying the heart for true and simple enjoyment.'[4]

During the twentieth century biological revolutions provoked by Charles Darwin and Gregor Mendel, the discovery of the structure of DNA and the mechanisms of its replication, transcription and translation, led botanists to unpick more fully the minutiae of plant workings. This chapter summarizes the influential role of botanical illustration in the history of botany.

Nature and wonder

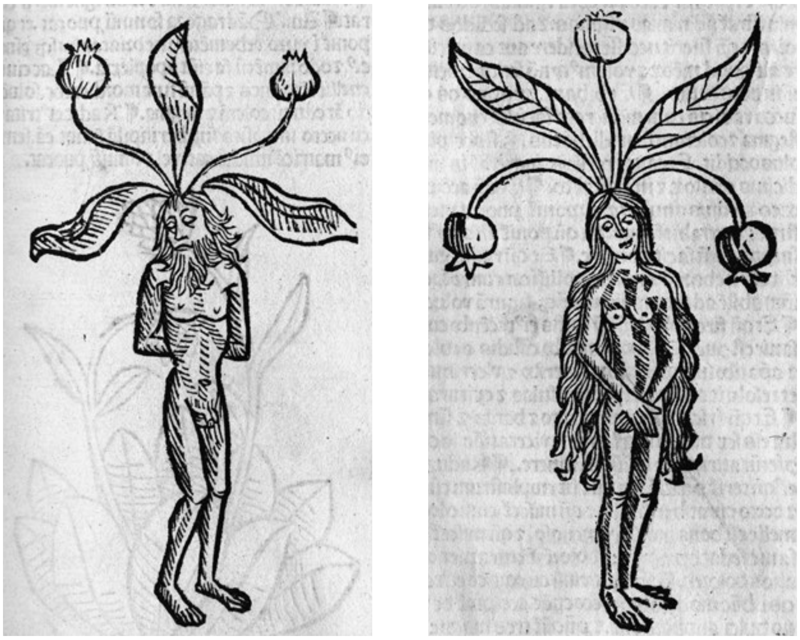
We are assailed daily with images of the natural world: images wrapped in narratives of mystery, designed to evoke emotional responses or create feelings of awe and envy. These include seasonal colour changes in temperate or desert landscapes with the onset of autumn or the rainy season, mass flowering and the subsequent demise of bamboos in western Chinese forests, and the overnight appearance of Neptune balls on Mediterranean beaches.[5] Wonder at the natural world is ancient, having contributed to the myths, folklore and religions of all human cultures.[6] Menageries, gardens and cabinets of curiosities – *Wunderkammern* (wonder rooms) – are theatres of the spectacular and palaces of wonder. Potentially, they are collections rich in eye-catching, rare and unusual objects, which preserve the singular, the dramatic and the fugitive to reflect the wealth, prestige and pretensions of their owners.[7] During the nineteenth century these collections also gradually became places of public education.

Peoples' responses to wonder can broadly be categorized as astonishment, prompting reverence or perhaps even fear, or admiration, provoking curiosity. Astonishment in pre-Renaissance Europe was a reminder of God's omnipotence and benevolence, while curiosity – St Augustine's 'concupiscence of the eyes' – was to be treated with suspicion.[8] Fifteenth- and sixteenth-century herbals, such as the German *Ortus sanitatis* (Garden of Health, 1491), were packed with woodcuts, of greater or lesser quality, that illustrated plants as meat, drink and remedies for body and soul. However, there were also images that were intended to provoke wonder, such as that of the mandrake.

Mandrake is native to the Mediterranean, where it has been used for millennia as an effective anaesthetic. However, few plants in Western botany are surrounded by so much nonsense. Speculation, wishful thinking, hand-me-down tales, protectionism and ritual have imbued it with an awesome reputation. 'Old wives', 'runnagate Surgeons' and 'physicke-mongers' would have us believe the homunculus-like roots emitted screams that were lethal to the harvesters who ripped them from the ground.[9] Moreover, its reputation ensured there was a market for mandrakes in European cabinets of curiosities, and that market was frequently supplied by artful dealers.[10]

Another botanical myth, that of the Central Asian barometz – a vegetable sheep tethered to the ground by its navel – was also a commodity of vigorous and lucrative trade. Enterprising Eastern traders fashioned these creatures from the hairy underground stems of an Asian fern, *Cibotium barometz*, whose scientific name commemorates this use.[11] One of these wonders is illustrated by the Swiss artist Christopher Switzer's woodcut title page of a landmark in English horticultural literature, John Parkinson's *Paradisi in sole paradisus terrestris* (1629) – literally 'Park-in-Sun's Earthly Paradise', a pun on the author's name. The wonder provoked by the plate is in whimsical contrast to the book's declared objectivity.

By the late 1660s the notion of wonder was changing. For members of the Royal Society of London, the purpose of cabinets of curiosities, bestiaries and herbals was no longer to inspire awe but to elicit curiosity – to help answer questions provoked by their contents. Rational explanations were sought for natural phenomena, and that required discipline, diligence and attention to detail, rather than reference to supernatural revelation.[12] The reward for such labour, as Bernard Le Bovier de Fontenelle, perpetual



Woodcuts of 'Andragora' (left)and 'Andragora femie' (right) from a late fifteenth-century Latin copy of the *Ortus sanitatis*, one of the earliest printed herbals. Traditional mandrake delineations are imaginative works, emphasizing the similarity of the plant's root to the human form, a fact that makes them useless as scientific documentation. In this case, the unknown artist(s) has not even attempted to depict either the plant's leaves or fruit correctly, suggesting that they may never have seen the living plant but copied stylized structures from earlier sources.

secretary of the eighteenth-century French Academy of Sciences, stated, was that 'nature is . . . never so wondrous, nor so wondered at as when she is known.'[13] By the end of the nineteenth century some Christian theologians had resurrected the argument that the natural world could be used to understand God. On receiving a copy of *On the Origin of Species* (1859) from Charles Darwin, the historian and social reformer Charles Kingsley went so far as to imply that a divine bump-start was responsible for setting the evolutionary charabanc in motion:

> All I have seen of it *awes* me; both with the heap of facts, & the prestige of your name, & also with the clear intuition . . . From two common superstitions, at least, I shall be free . . . 1) I have long since, from watching the crossing of domesticated animals & plants, learnt to disbelieve the dogma of the permanence of species. 2) I have gradually learnt to see that it is just as noble a conception of Deity, to believe that he created primal forms capable of self development.[14]

Science: Ways to think

In the first millennium of the Common Era Greek botanical knowledge was lost to Western Europe.[15] During the first centuries of the second millennium, Muslim and Christian cultures came into contact in southern Europe.[16] Greek manuscripts on plants and many other subjects, held in the Arab world, were translated into Latin, particularly at the Schola Medica Salernitana in Salerno, southern Italy. In this way Western Europe rediscovered ancient Greek science, spurring humanist ideas of the Renaissance.[17] Whereas ancient Greek philosophies viewed humans as part of nature, Christian doctrine interpreted humans as apart from it.[18] Earth was the centre of a universe created fundamentally for humans; everything was subservient to the caprice of *Homo sapiens*. Moreover, the doctrine interpreted the world as having fallen into corruption, and saw the natural world as merely a backdrop to humanity's spiritual quest.

Discoveries that challenged old ideas were met by some people with carefully finessed arguments that realigned the evidence to fit existing orthodoxies. Others, such as the English philosopher and statesman Francis Bacon, 'father of the scientific method', believed that natural philosophers must be methodical, sceptical and willing to abandon handed-down authority. Rather than taking an unproven hypothesis and reasoning from the general to the specific in order to test empirical observations, he said, reasoning must begin with specific observations that lead to probable, general hypotheses.[19] The founders of the Royal Society in 1660 were influenced by the society portrayed in Bacon's unfinished Utopian fantasy *New Atlantis* (1627).[20] The Society also quickly recognized the importance of ensuring that its ideas were widely communicated. Within five years of its foundation, its first major publication, Robert Hooke's *Micrographia; or, Some Physiological Descriptions of Minute Bodies Made by Magnifying Glasses. With Observations and Inquiries Thereupon* (1665), was in circulation.[21]

By the mid-twentieth century ideas of the way science should be carried out embraced the objective testing of hypotheses. Under this approach, a theory capable of being tested and falsified is accepted until hypotheses arising from it are rejected. At the heart of what modern scientists do is the precept that through an interactive process of observation,

hypothesis, experimentation, evaluation and retesting, the natural world can be understood. Consequently, science is fluid and constantly evolving, changing our view of the world as new facts are accommodated into existing ideas, or unproved ideas jettisoned. However, science does not operate in isolation; scientists are influenced by their predecessors, their peers and the places, periods and societies in which they live.[22]

Humans are extremely good at recognizing patterns – often too good; consider how readily faces are seen in cloud formations. In separate but synergistic manners, scientists (natural philosophers) and illustrators seek to summarize, gauge and understand the complexity of nature. Scientists wrestle with numbers, measurements and equations as they learn to survey, quantify and dissect the natural world. Similarly, illustrators struggle with objectivity as they discover pictorial conventions to reveal, depict and condense natural variation. A series of lines on a piece of paper may appear to capture the morphology of a plant more effectively than any number of measurements, but how do images and numbers relate to each other, and are they objective?

Living laboratories and dried gardens

Botanic gardens, as collections of plants grown for leisure or the convenience of study, are ancient. In contrast, herbaria – that is, libraries of dried plants sometimes called 'dry' or 'winter gardens' – have been part of the study of plant diversity only since the mid-sixteenth century.[23] With the resurgence of European interest in the natural world, physic gardens emerged as part of the medical faculties of such ancient Italian universities as Pisa (1543), Padua (1545) and Bologna (1568). Bologna is also the place where the botanist Luca Ghini made the first herbarium specimens.

Within a century, many European universities were investing in living collections of medicinal plants that added lustre to their reputations and created space for scholars to meet and teach. In 1658 the physician who 'be puffed up with vain perswasion of his own abilities, and shall think because he hath the title of Doctor he may be as idle as he please, and slight the study of Simples [fundamental ingredients of medicines]' was warned that the contents of Oxford Physic Garden (founded 1621) might have something to teach him.[24]

Engraving from 1720 of a European fan palm growing in the Padua Botanic Garden, which was planted in 1585 and, carefully protected against the elements, still survives. The garden's director, Giulio Pontedera, included this image by an unknown illustrator and engraver among his catalogue of the garden's plants. The palm, which appears to have been coppiced at the base, is in flower, but there is nothing to indicate scale to a reader unfamiliar with the plant.

TAB. VIII.

Chamæriphes Tricarpos,
Spinosa, Folio Flabelliformi.

At Padua, the botanic garden, protected by its distinctive circular wall broken by gates at the cardinal points, was founded by the Venetian Republic for the teaching of medicine, and was surrounded by apothecaries' workshops.[25] The garden proved so popular with visitors that in 1591 the Italian woodcutter and engraver Girolamo Porro published plans of the garden, together with blank, numbered pages corresponding to the garden's numbered beds, so that visitors could record the identity and position of the garden's contents.[26] In 1720 the director of the garden, Giulio Pontedera, enumerated and illustrated some of the garden's trees.[27] One of these was a specimen of the European fan palm planted in 1585. This palm, which survives to the present day, is famous not only for its longevity but because the German poet Johann Wolfgang von Goethe saw it on his Italian tour (1786–8) and used it in his *Versuch die Metamorphose der Pflanzen zu erklären* (Metamorphosis of Plants, 1790), in which he presents his ideas that the petals of flowers are modified leaves.[28] Unlike Goethe, John Sibthorp, who had travelled through Italy a few months earlier, was dismissive of the state of Italian horticulture: 'indeed Italy in respect to gardening is greatly behind her neighbours & more than a century behind England.'[29]

Botanic gardens, whose primary purpose was the cultivation of medicinal plants, soon gave way to gardens growing plants for scientific purposes, especially the naming and ordering of global plant diversity. In Paris, the Jardin du Roi, established in 1626 as a physic garden by the French monarchy under the charge of Guy de La Brosse, evolved over the course of the following 150 years into the premier botanical institution in Europe.[30] The Royal Botanic Gardens, Kew, established as a royal pleasure ground in 1759, acquired its present scientific role under the leadership of the botanist and illustrator William Jackson Hooker in 1842.[31] Moreover, networks of botanic gardens became central to the colonial aspirations of European powers during the eighteenth and nineteenth centuries, their purpose to facilitate the movement of plants across empires and to capitalize on wealth extracted from plant products.[32]

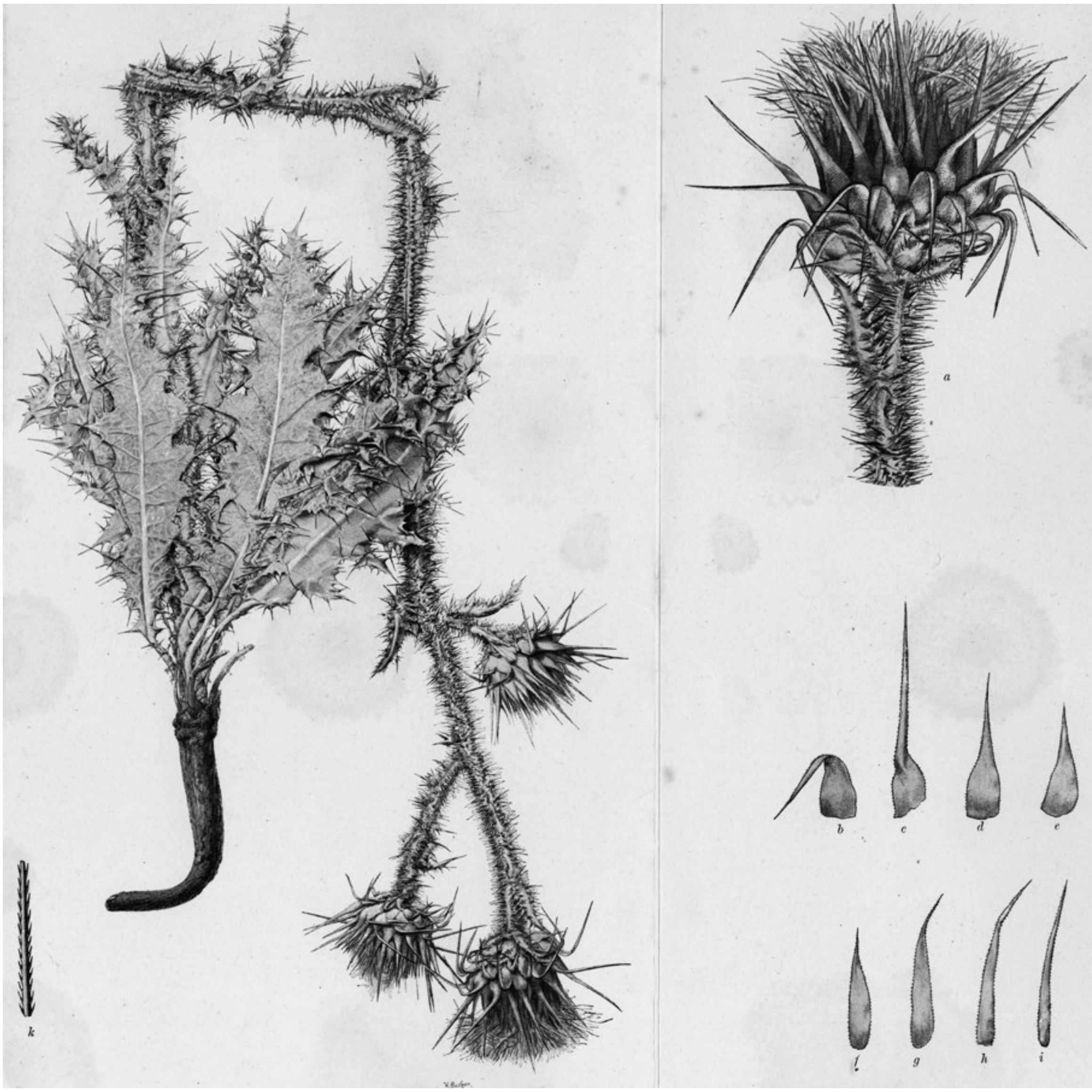
Plants contribute directly to commerce, producing profits and ultimately power. In 1681 the plant anatomist Nehemiah Grew, who catalogued the Royal Society's museum, emphasized the immense economic value of even poorly known plants: 'The Jesuites Barque [Andean quinine tree], of which, no Man yet hath well describ'd the Tree, and very few know

precisely where it grows; yet what great quantity, doth the much use of it bring over to us? Unicorns Horns, upon the like motive of trade, would be as plentiful as Elephants Teeth.'[33]

Botanic gardens allowed novel plants to be cultivated, the productivity of potentially economic plants to be compared (and those plants perhaps even acclimatized to new environmental conditions), and information about living plants to be exchanged. In Britain, between 1762 and 1766, the Society of Arts offered rewards to anyone who 'should cultivate a spot in the West Indies in which plants, useful in medicine and profitable articles of commerce might be propagated and where a nursery of the valuable products of Asia and the distant parts might be formed for the benefit of His Majesty'.[34] When the body that would become the Royal Horticultural Society was established in 1804, another organization for exploiting imperial plants was created. Imperial gardens became important players in the global movement of such plants as coffee, quinine, rubber and tea from their native ranges to areas under European control. In other cases, colonial networks of botanic gardens enabled European powers to wrest control of valuable plant monopolies from one another. In the late 1760s, for example, the Netherlands lost her nutmeg and clove monopolies to France when the French horticulturalist Pierre Poivre 'stole' these species and successfully established them in Mauritius and La Réunion.[35] Botanical illustrators found that their skill was vital to all aspects of the use of and prestige to be derived from these living collections.

As scientific and economic collections, botanic gardens were complemented by herbaria, which are collections of specimens that link a plant's identity with evidence of its occurrence in a particular time and place. It has been said that 'a collection of living and dried plants should always go together': living plants generate initial botanical enthusiasm plus the means to understand details of plant structure, while dead plants give access to species that are impossible to grow all year round.[36] Today, worldwide, there are some 3,000 herbaria, containing approximately 390 million species.[37]

Whereas modern herbarium specimens are mounted on single sheets of card, many pre-eighteenth-century herbaria are bound like books. In the eighteenth century, Linnaeus identified best practice for the preparation, labelling and organization of herbarium specimens, and these techniques



differ very little from those used today. Fresh plants, with fruit and/or flowers, are spread out between sheets of paper and dried quickly in a press, which keeps the specimens flat. Once dried, the specimens are mounted on separate sheets of paper, together with their labels. This simple technology produces specimens that, if protected from dust, fungi and insects, last indefinitely. As we have seen, the scientific value of a botanical illustration is enhanced when it is supported by a preserved specimen (called a voucher) stored in a permanent, publicly accessible collection.

Black-and-white relief halftone of an endemic Cypriot cotton thistle based on an original illustration by H. Berger, 'drawing-artist' at University Museum of Bergen, Norway.[38] The voucher for Berger's illustration is an herbarium specimen collected by the Norwegian botanist Jens Holmboe, which was used to describe a new species, *Onopordum insigne*, in his *Studies on the Vegetation of Cyprus* (1914). Today, this species is considered synonymous with the more widespread *O. bracteatum*.

Natural-history collections evolved from cabinets of curiosities into essential tools for the accurate classification and naming of plants, and for communicating information about life on Earth.[39] This change was accompanied by a move away from collectors wanting one of everything, to wanting their specimens to be representative of the variation of species across their entire geographic ranges. Currently, many botanic gardens are primarily spaces for recreation and education. Yet they were once scientific tools to facilitate the comparison of living plant species, grown under similar environmental conditions, throughout their life cycles. Moreover, botanic gardens, as research organizations, were foci for scientific botanical illustration. Illustrators could work in relative comfort, study plants under optimal conditions at all times of the year, and compare species that would not ordinarily be found growing together. Such functions can of course be achieved on modest patches of soil, but since their inception, botanic gardens have also been canvases for botanical display, where elaborate architecture and planting designs show off power, advertising the status and pretensions of host institutions and their founders.

Naming and classification

Botanical illustrators have been pre-eminent in recording the diversity of plant life accumulated by botanical collectors through global exploration. However, if such diversity is to be economically exploited and intellectually explained, it is necessary to have systems of naming and classification. Giving a plant a name is an essential first step in understanding its biology and facilitating communication about it among cultures and across generations. However, mere lists of names are insufficient for the synthesis, storage and retrieval of botanical knowledge; classification systems are necessary to bring order to names. Imagine using a dictionary in which the words are randomly arranged.

A plant's name should refer unambiguously to one thing and be understood by everyone. Common, vernacular or trivial names are used in everyday life, but these same organisms also have scientific names. Indeed, all known plants have scientific names; relatively few have common names. Common names enjoy neither uniformity nor international recognition, since they reflect people's traditions, beliefs and prejudices. A scientific name, on the

other hand – which sometimes says much about the prejudices of the botanist who coined it – aims at stability, is applied unambiguously and is understood across language barriers. Early modern natural philosophers adopted a system of naming based on short Latin descriptions called polynomials. For instance, 'Arum vulgare non maculatum' (common non-spotted arum) was used for the plant whose common names in English included cuckoo pintle, wake Robin and priest's pintle, in German *Pfaffenpint*, in Russian Аронник, and in French *pied d'veau*.[40] The plant's modern scientific, or binomial, name, *Arum maculatum*, was first used by Linnaeus in his *Species plantarum* (1753).

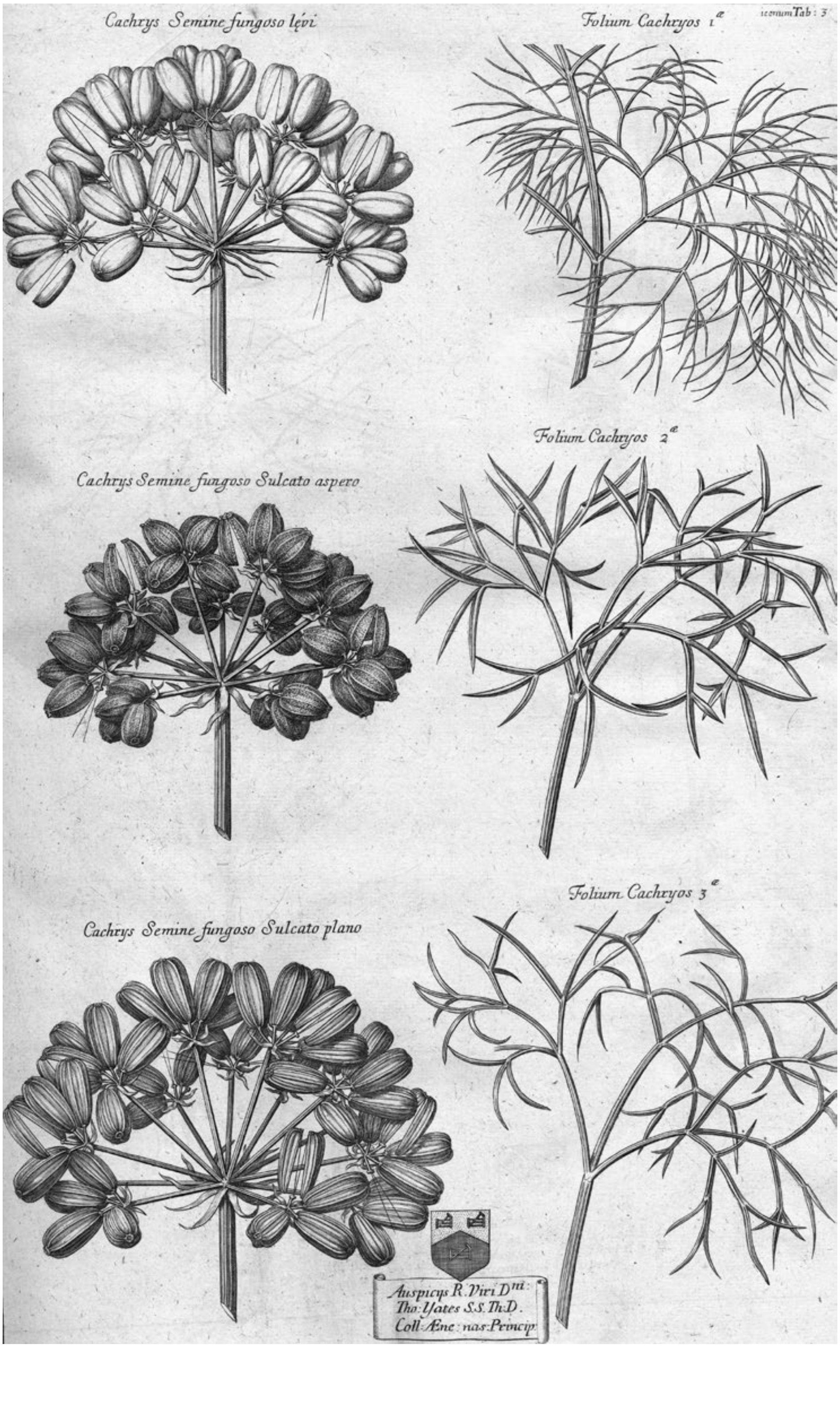
Conventions are essential to reduce the problem of scientific names becoming a lexicographical Babel. The superficially tedious rules of botanical nomenclature have since 1867 been set out in a regularly updated code, now known as the *International Code of Botanical Nomenclature for algae, fungi, and plants*. Among these rules is the requirement that every name be associated with a physical specimen – the type specimen – held permanently in a publicly accessible natural-history collection. Since the type specimen may not be representative of the species, it must also be accompanied by a description. New research or the discovery that species are known by other scientific names (synonyms) means that sometimes, with reluctance, names must be changed to comply with the *Code*.

By the sixteenth century two major questions were pressing. What were the best features to distinguish plant species? What were the best ways to group the diversity of plants? All manner of 'essential' features were investigated, ranging from roots and leaves through habit, flowering time and habitat to the use or supposed medicinal value of the plant, and usually published in unillustrated tomes. One of the more prominent of these so-called pre-Linnaean classifications was published in Andrea Cesalpino's *De plantis libri* (Books on Plants, 1583), which placed emphasis on the structure of fruit.

In the eighteenth century, Linnaeus proposed a classification system that ordered the whole of life:

> The Animal, the Vegetable & the Fossil Kingdoms marched in a new but regular Order into his System and he [Linnaeus] supported it by Laws so well contrived & devised that the Appearance of a new

Copper-engraved plate of the fruit and leaves of three members of the carrot family, from Robert Morison's *Plantarum umbelliferarum distributio nova* (1672). This volume was designed to promote Morison's fruit-based classification system, based on the work of Andrea Cesalpino in the late sixteenth century, and to raise funds to illustrate his subsequent work. Each plate bore the name of a sponsor, in this case Thomas Yates, Principal of Brasenose College, Oxford, between 1660 and 1681.


iconum Tab: 3
Cachrys Semine fungoso lęvi
Folium Cachryos 1ae
Folium Cachryos 2ae
Cachrys Semine fungoso Sulcato aspero
Folium Cachryos 3ae
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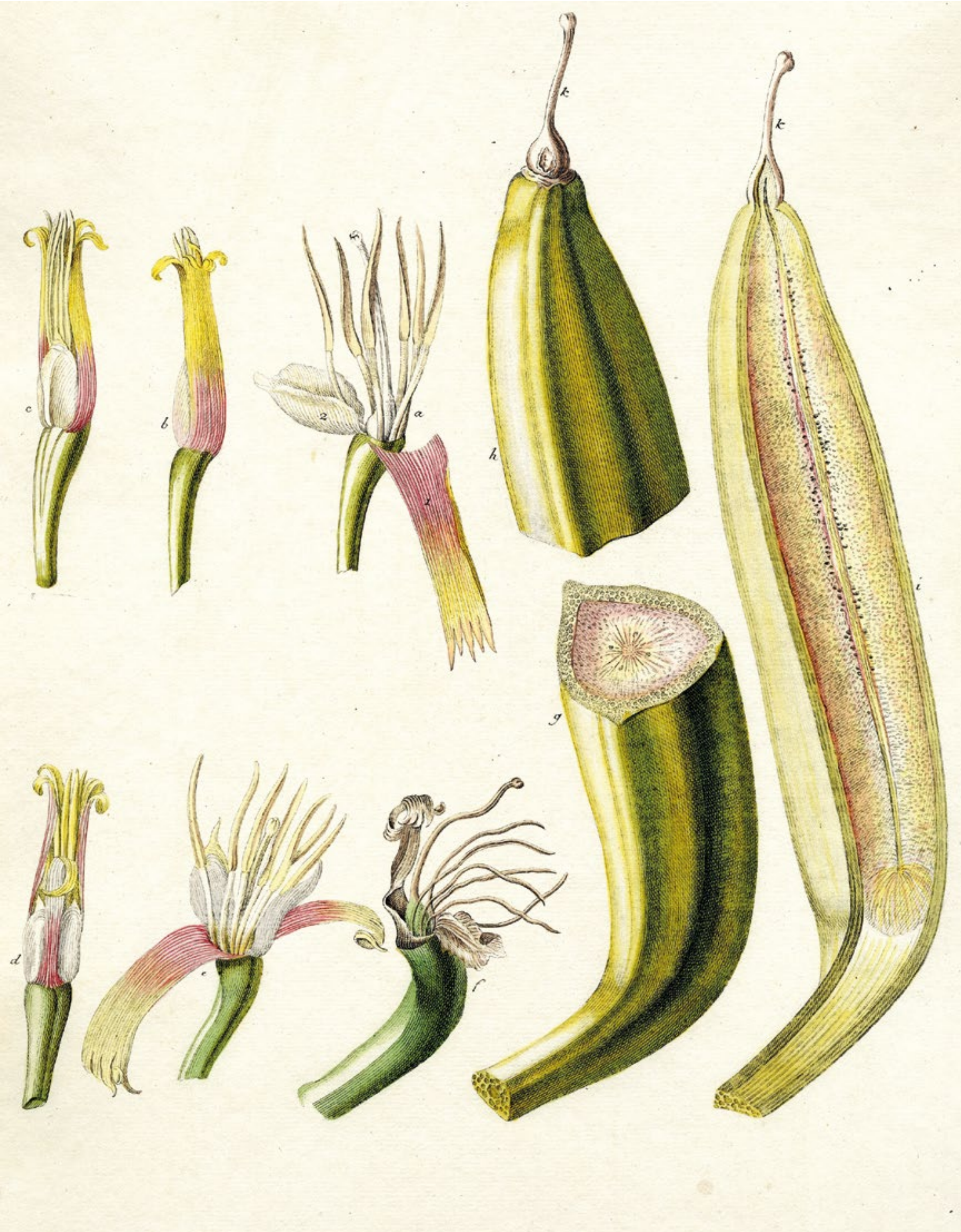


Hand-coloured engraving showing details of a banana flower and sections through the fruit from the German botanist Christoph Jacob Trew's *Plantae selectae, quarum imagines ad exemplaria naturalia Londini in hortis* (Selected plants, the pictures of which are from specimens in London gardens; 1750–73). The original drawings were made by the German illustrator Georg Dionysius Ehret and acquired by Trew, who commissioned the Augsburg engraver Johann Jacob Haid to prepare the plates. The illustrations Trew selected for publication were of novel plants rarely found in cultivation in eighteenth-century Europe.

Michel Adanson's name is associated with the enormous, widespread African baobab, *Adansonia digitata*, a tree he first saw on islands used by slave traders off the coast of Dakar, Senegal, in 1749. William Jackson Hooker's illustration of a flower preserved in alcohol and engraved by Joseph Swan was published in *Curtis's Botanical Magazine* in 1828. The tree cannot flower in British glasshouses, so Hooker asked his horticultural audience's indulgence: 'I trust, that representations of so great a rarity . . . from drawings made in India . . . and from specimens . . . sent to me in spirit, by [the theologian and naturalist] Mr [Lansdown] Guilding, from St Vincent, may be generally acceptable to the Botanical world.'[41]

> Plant or a new Animal occasioned neither Confusion nor Disorder. The One or the Other readily found its Place. The Number of Links were increased but the Chain was not disturbed.[42]

Linnaeus classified plants into twenty-four 'classes' based primarily on the arrangement and number of male (stamens) and female (pistils) parts in the flower.[43] Thus, the class *Monandria* had one stamen, class *Diandria* had two, class *Hexandria* six and class *Tetradynamia* four long and two short stamens. Moreover, his system was illustrated by his favourite botanical illustrator, Georg Dionysius Ehret. The explicit language chosen by Linnaeus to explain his system made it controversial among some botanists, clergy and other members of society.[44] Notoriously, Johann Siegesbeck, Demonstrator of the botanic garden in St Petersburg, was concerned that 'such loathsome harlotry' and 'so licentious a method' was being taught to students, while Samuel Goodenough, Bishop of Carlisle, stated that 'nothing could equal the gross prurience of Linnaeus's mind,' and that 'Linnean botany is enough to shock female modesty.' Linnaeus's system enjoyed wide currency, especially in England, but more thoughtful – and ultimately devastating – intellectual, rather than moral, arguments would be mounted against it, especially by French botanists.[45]

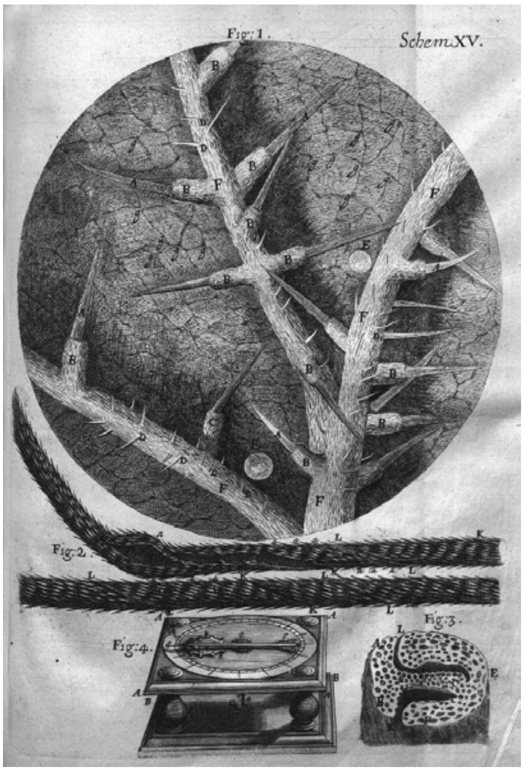
One of these men was Michel Adanson, who at the age of 21 was employed by the French East India Company to undertake a five-year exploration of Senegal. Adanson, who is credited with being the 'first philosopher, who adventured to visit the torrid zone, for the propagation of knowledge', rather than as an adventurer for the 'purchase of slaves, teeth and dust', collected plants and animals, drew maps, made meteorological and astronomical observations, and studied African languages.[46] Based on these experiences, he rejected the notion that there were 'essential' features of plants that were automatically more important for classification before plants were studied in detail.[47] Rather, he argued, all features were equally important until detailed study revealed otherwise. Such natural classifications became established in botany during the early nineteenth century, ousting artificial systems (including that of Linnaeus), and have flourished to the present day.

Before the early twenty-first century the road to classification was paved with morphological characters, depicted carefully by generations

of botanical illustrators. Today, the backbones of plant classification are sought in chemistry and computing, as complex algorithms unravel and compare DNA strands to reveal the relationships among species. Botanical illustrators have no place in these processes, but may be critical for communicating such highly abstract results.

Brass and glass

Technology enables people to look beyond the limits of their vision, to reinterpret and remake the world. Henry Power, an English physician and experimentalist, published the first work in English on the world revealed by the microscope. His words drew readers into a sphere of 'prety Engines'.[48] His countryman the natural philosopher and architect Robert Hooke used copper engravings and etchings of his own drawings to similar devastating effect. Across 38 copperplates in *Micrographia* (1665), Hooke apprehended the European scientific spirit, the philosophy of the Royal Society and its motto, *Nullius in verba* (take nobody's word), to begin the creation of a visual language for displaying nature magnified.[49]



Black-and-white engraving of the magnified lower surface of a common nettle leaf, published in Robert Hooke's *Micrographia* (1665). The *Micrographia* was the first book published by the Royal Society of London, and became one of the most influential books of the late seventeenth century. The illustration, made by Hooke, shows stinging hairs (A and B) and bristles (D) arranged along the leaf veins.

Inside a circular pool of light, defined by the lens of the monocular microscope through which he peered, Hooke captured the magnified lower surface of the common nettle leaf – an object probably as familiar to both sight and touch in the seventeenth century as it is today. Three girder-like veins, which stretch the leaf blade flat, are ornamented with 'turn-pikes', 'sharp needles' and 'bodkins'. Among the short, bristle-like hairs are long, bulbous-based ones with slender points. The latter are stinging hairs, which Hooke went on to confirm by experiment, describing the 'little bagg of green Leather' surmounted by a 'Glyster-pipe'. He speculated that the 'bagge', with 'the shape and surface of a wilde Cucumber', contained a poison that was discharged when the 'Glyster-pipe' penetrated human skin.[50] Hooke had begun his microscopical examination because he wanted to explain how 'pain is so suddenly created, and by what means

continued, augmented for a time, and afterwards diminish'd, and at length quite exstinguish'd'.[51]

People who are familiar with looking at objects under a monocular microscope may find Hooke's images disturbing.[52] Rather than being two-dimensional images, as observed under the microscope, Hooke's images are presented in three dimensions. The illusion of the third dimension is created through a skilful collaboration between Hooke as the observer-illustrator and the engravers and etchers who transformed his drawings into the copperplate from which the image in the *Micrographia* was pulled:

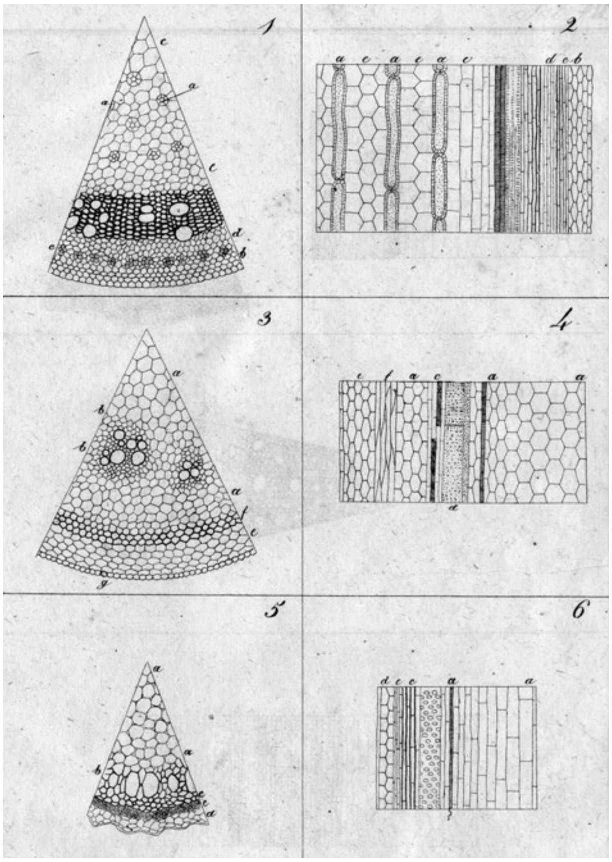
> the Gravers have pretty well follow'd my directions and draughts; and that in making of them, I indeavoured (as far as I was able) first to discover the true appearance, and next to make a plain representation of it. This I mention the rather, because of these kind of Objects there is much more difficulty to discover the true shape, then of those visible to the naked eye, the same Object seeming quite differing, in one position to the Light, from what it really is, and may be discover'd in another. And therefore I never began to make any draught before[,] by many examinations in several lights, and in several positions to those lights, I had discover'd the true form. For it is exceeding difficult in some Objects, to distinguish between a prominency and a depression, between a shadow and a black stain, or a reflection and a whiteness in the colour. Besides, the transparency of most Objects renders them yet much more difficult then if they were opacous.[53]

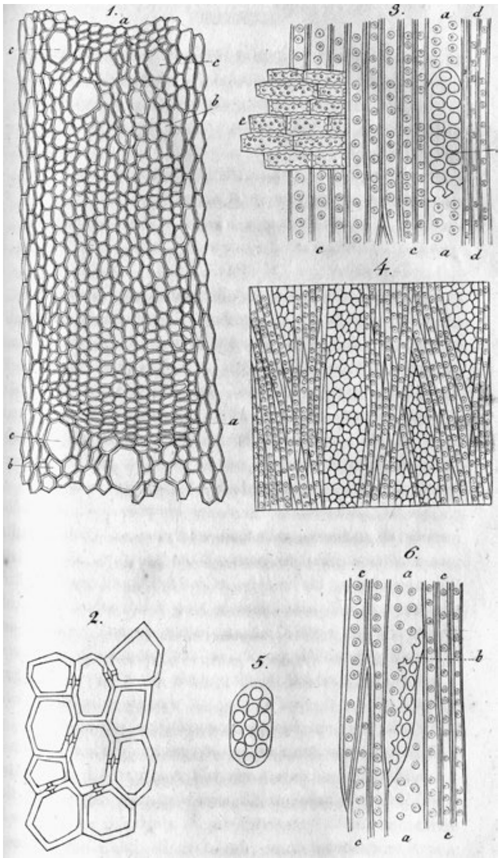
Hooke's image forces us to confront the familiar in unfamiliar ways, producing a sense of wonder at the 'least work of Nature'.[54] However, to understand nature scientifically, wonder must be tempered with focus, diligence and scepticism. Hooke's image – like all botanical illustrations – is limited by the technology of the time. Push the technology a little further and there is the possibility of revealing more, perhaps even bringing one closer to answering Hooke's original questions.

The full botanical potential of the microscope began to emerge as low-priced, high-quality instruments were made and marketed in Germany, France and Austria, and microscope lenses were developed that overcame

problems of image distortion.[55] The self-taught German botanist Hugo von Mohl was instrumental in the development of the microscope as a botanical tool, with the accolade of being the first to observe the fundamental process of cell division. Towards the end of the nineteenth century, illustrations he had produced in 1827 were described as 'antiquated', while those he produced a few years later were 'thoroughly modern [in] appearance' – a testament to the optical improvements made to the microscope over just a few years in the 1830s.[56] As the technology of microscopy evolved, botanical illustration remained a crucial means for naturalists to interpret what they observed under the microscope. Moreover, illustrations mediated between the observer in the laboratory and the reader of scientific conclusions presented in books and journals.

In the late 1930s, towards the end of his career, the British botanist Frederick Orpen Bower reflected on his training in Germany under Julius von Sachs, who led him into the practice of exact delineation, being





Engraved plates of illustrations made by Hugo von Mohl showing the appearance of transverse and vertical sections through plant structures, demonstrating improvement in the optical quality of microscopes in 1830s Europe. In 1827 (left) Mohl's illustrations are reminiscent of Nehemiah Grew's seventeenth-century images. By 1831 (right), the illustrations, engraved by the German engraver and botanical illustrator Friedrich Guimpel, reveal surface features associated with individual cells.

himself a master of it. I remember his saying to me cryptically, pencil in hand, 'every drawing conveys a view': and I have never forgotten his hyperbolic aphorism 'that no one has really seen an object until he has drawn it'. Thus I learned the advantage of hand-drawing, aided or not by the camera lucida. Photography which has so largely superseded it in later years has drawbacks, notwithstanding its greater accuracy. Sachs's own illustrations are among the most explicit ever published, and may be taken as expressing his considered views. Modern photographs often fail adequately to present the object itself, and they never convey a personal view. It may, however, remain an open question how far this last is a real advantage.[57]

Physiology and experiment

Linnaeus's hierarchical classification of the natural world was mirrored in his separation of those interested in plants into 'us' and 'them'; the true 'botanists [us] . . . considered physiological and anatomical researches [them] generally to be of secondary importance, if not mere trifling.'[58] However, the sands of scientific botany were shifting.

Until the late eighteenth century men and some women of both property and leisure were necessary for the development of botany. From the early nineteenth century, as science became integral to economic growth, industrialists emerged as major botanical patrons. While industrialization established links among botany and other physical sciences, it also created botanical specialisms that justified themselves in terms of economic productivity, as they competed for respectability, recruits and resources.[59] Some botanists commanded respect across specialisms. Robert Brown worked on both plant diversity and anatomy, for example, coining the term 'nucleus' for the DNA-containing part of a cell, based in part on illustrations by Franz Bauer.[60] In continental Europe, French and German botanists focused their attentions on anatomy, physiology, cell biology and biochemistry. The turmoil and abrasion of nineteenth-century academic disputes polished many of the ideas on which modern plant sciences are founded.

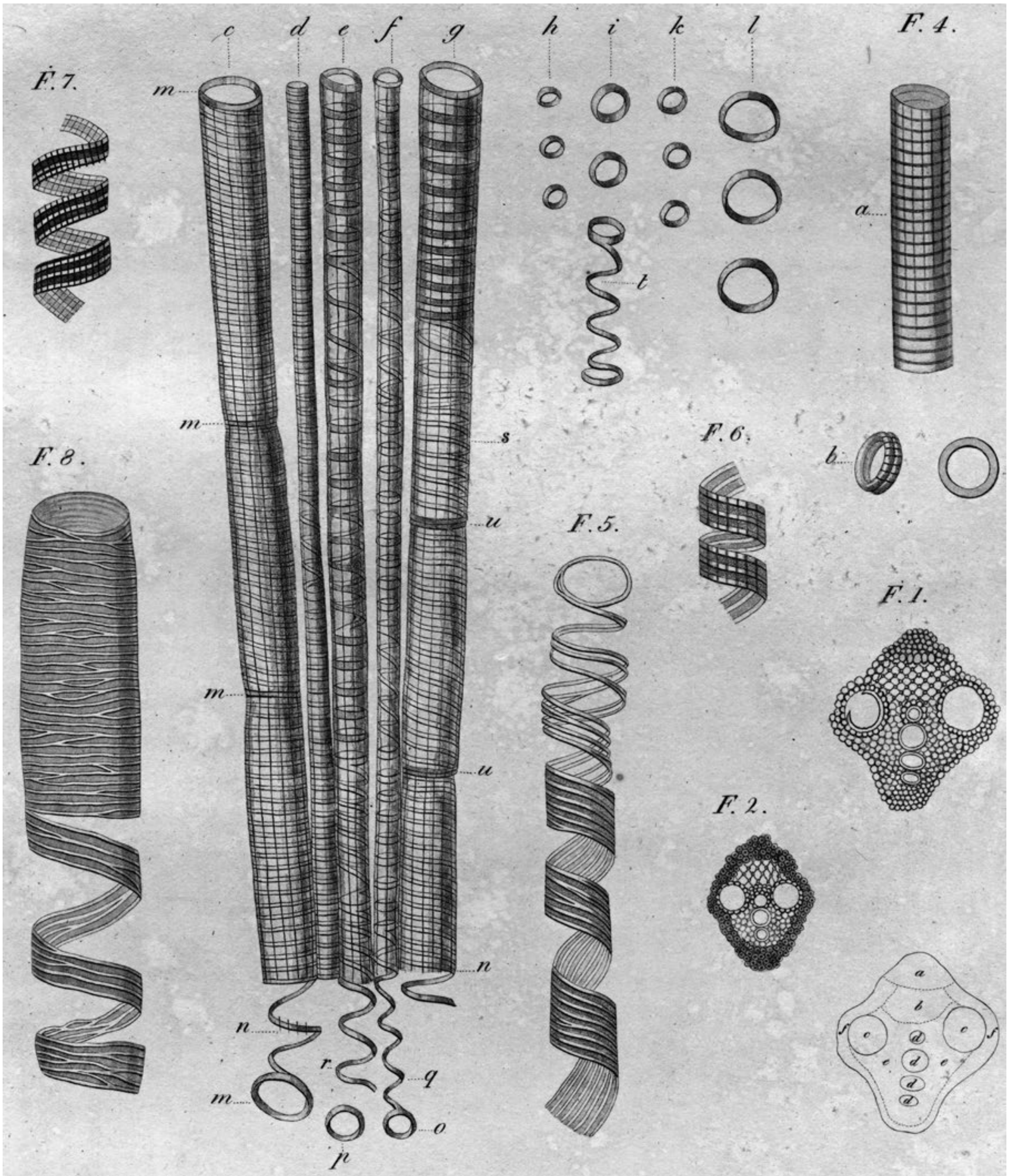
In the seventeenth century microscopical examination of thin slices of cork led Hooke to conclude that it was made up of 'many little Boxes', which he christened 'cells'.[61] Nearly 150 years later the German botanist Johann Jacob Paul Moldenhawer developed the technique of maceration,

whereby plant tissues could be readily broken apart so that whole cells could be examined, rather than just sections through them. Such investigations, using numerous different types of tissue and microscope, led Moldenhawer to argue that plants were composed entirely of cells of different shapes, sizes and functions. When he published his results, which included six copperplate engravings, in 1812, Moldenhawer took pains to convince his audience of the veracity of these images and his observations:

> [The] figures . . . were made by a woman [his wife, Henriette Moldenhawer], the rest by an extremely skilled artist, Mr Lüderitz in Kiel . . . only when I myself saw the object clearly in all its parts, and others to whom I showed it saw the same without my remark, did I leave the illustration to the draughtsman . . . Even if I saw the object depicted with the greatest fidelity and fearful care, the unanimous judgement of the knowledgeable and uninformed of the drawing would still have to express the seal of authenticity.[62]

The self-taught German botanist Wilhelm Hofmeister has been described as a 'real genius, such as appear in science only between long intervals of time'.[63] At the age of 27, while still employed in his father's book business, Hofmeister published an account of plant reproduction that revolutionized botany by unifying the life cycles of all plants, reinforcing the key role of cells in our understanding of plant organization and development. One late twentieth-century historian of botany emphasized that Hofmeister's genius was 'firmly based on a consummate mastery of microscopical technique, unique powers of observation and critical interpretation, and an ability to delineate what he saw with impressive accuracy and beauty'.[64]

Industrial raw materials, such as timber, fertilizers and chemicals, were cultivated or extracted from natural plant populations, so imperial botanists prioritized creating ledgers of botanical assets, filling collections with herbarium specimens and illustrating these discoveries. However, by the 1870s some were arguing that such 'restricted channels' were stifling British botanical innovation, especially compared to what was happening on the continent.[65] In his botanical textbook *Grundzüge der wissenschaftliche Botanik* (Principles of Scientific Botany, 1842), which was dedicated to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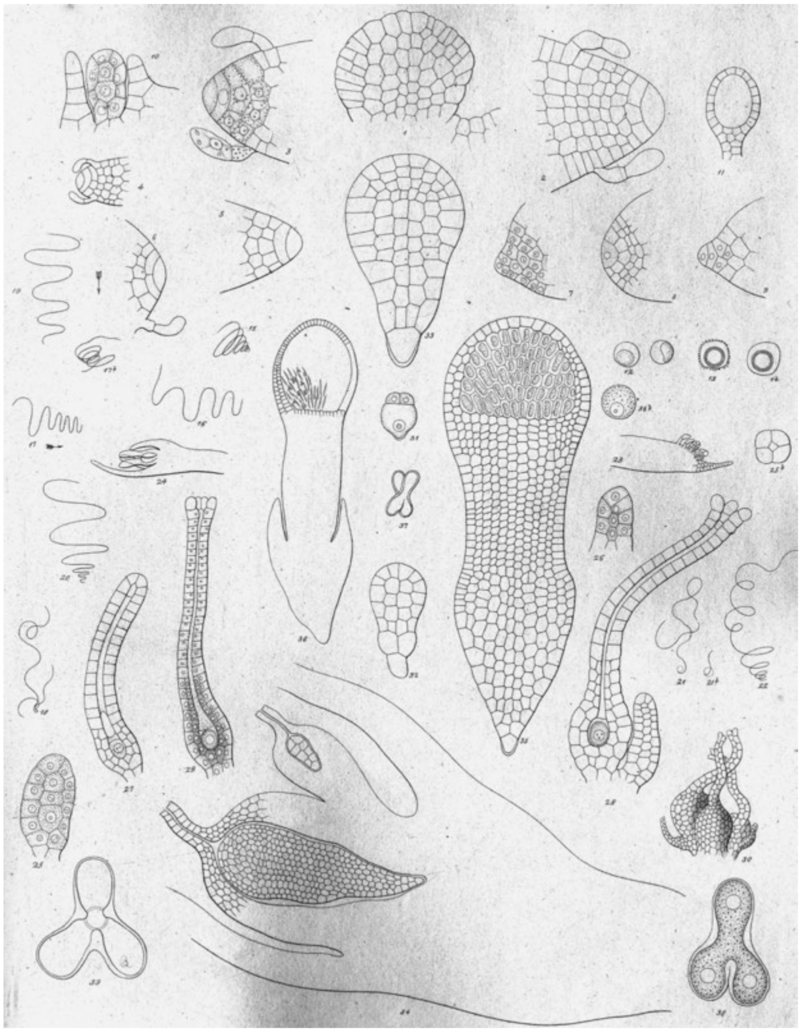


Wilhelm Hofmeister's drawing from his book of 1851 showing microscopic details of development in the northern hemisphere liverwort *Pellia epiphylla*. Among structures shown in A. Gebhart's engraving of Hofmeister's illustration are motile male sperm (centre left) and egg cells at the bottom of elongated flasks (right). Detailed comparisons of such plates demonstrated that all plant life cycles were similar, a fundamental mid-nineteenth-century botanical discovery.

Illustration of the different sorts of cell that make up plant stems. These cells were chemically separated from each other by a process called maceration, prepared for viewing under a microscope, then drawn by Henriette Moldenhawer in 1812. The preparations were made by her husband, the German botanist Johann Jacob Paul Moldenhawer, while the copper plate was engraved by G. A. Forsmann. Such images were familiar in botanical textbooks until the latter half of the twentieth century.

the polymath Alexander von Humboldt, the German botanist Matthias Jakob Schleiden asserted that 'it is the physiology of plants which is alone of use. A knowledge of the systematic arrangement of plants is only of importance to the botanist: for all others it is a pastime, if not a waste of time.'[66] Schleiden emphasized that there were specialisms in botany, implying that ordering plant diversity was not science – a view that would resonate within plant sciences during the twentieth century.[67] Over 564 pages of densely printed text, he started by investigating the simplest plants, then passed on to gradually more complex forms, but considered images unnecessary for his arguments; words and numbers were his currency of communication.

Research into the science of plants was developing in directions that presented challenges to traditional botanical illustrators, who could no longer rely on the support of public institutions or private patronage. Moreover, photography was developing rapidly as a method of recording botanical data, especially within laboratory and experimental contexts, where observational skill other than the ability to draw was emphasized. However, during the twentieth century, as their unique skills once more became appreciated, botanical illustrators were gradually reintegrated into wider botanical practices.

Evolution and genetics

The French naturalist Georges-Louis Leclerc, better known as the Comte de Buffon, insisted that natural philosophers accumulate accurate factual data before articulating their theories. Botanical illustrations, together with dried specimens and measurements and other observations of the natural world, contributed to this factual corpus. Centuries of work by natural-history illustrators had documented the diversity of plants and animals. Assuming illustrators worked from their own observations, rather than just copying the work of others, such illustrations may reflect individual differences across the distribution of each species. By the end of the eighteenth century it was only a matter of time before the dogma of divinely fixed, immutable species would be wholly rejected.[68]

In 1800 the French naturalist and evolutionary theorist Jean-Baptiste Lamarck proposed his idea of the inheritance of acquired characteristics, that is, that parents pass on to their offspring the physical characteristics they use during their lifetime. However, for a hypothesis to be acceptable, it must explain all observed facts, rather than a selection of them. The more the natural world was explored, the more exceptions to Lamarck's ideas were discovered. In 1859, after decades of vacillation, Charles Darwin published *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* – one of the most influential books ever written. He had amassed evidence from nature and from animal and plant breeders to demonstrate the variability of species and the importance of variation for species' survival, and proposed means by which species could evolve. However, a century

Copperplate engraving of the garden pea made by the Scottish illustrator Elizabeth Blackwell for her *A Curious Herbal* (1737–9; original hand coloured). With the endorsement of some of London's leading physicians and apothecaries, Blackwell used living models from the Chelsea Physic Garden, under the direction of Isaac Rand. The 500 illustrations in her *Herbal* fulfilled two functions: to provide accurate contemporary illustrations of the plants used in early eighteenth-century English medicine, and to raise money to pay the debts accumulated by Blackwell's husband, Alexander.

of debate followed before his general mechanism of evolution was widely accepted.

Despite the elegance of Darwin's ideas, he failed to resolve how information was passed across generations. At a Czech monastery in Brno, in quantitative, experimental investigations using garden peas, the Moravian monk Gregor Mendel, who had trained as a physicist, discovered a solution to the problem. Mendel's experiments showed that forms of traits (genes) are inherited from each parent and transmitted unchanged from one generation to the next. An individual's appearance is a consequence of reshuffling genes from previous generations. Despite having a copy of Mendel's work, Darwin failed to grasp its significance for his own ideas.

This insight came at the start of the twentieth century, as the new science of genetics was born. One of the rediscoverers of Mendel's work was the Dutch botanist Hugo Marie de Vries, who investigated the processes underlying patterns of diversity in evening primroses.[69] When de Vries, an accomplished botanical illustrator in his own right, published his research in 1913, he complemented 120 black-and-white photographs with 22 coloured plates. As an author, he used his authority to emphasize the authenticity of the images: 'drawings for the coloured plates were made from nature and at natural size, by the painter M. A. [Marinus Adrianus] Koekkoek, but then reduced for printing. The photographs for the text figures were taken in my experimental garden under my direction.'[70] Such syntheses, together with the localization of genes on chromosomes, which are made of DNA, have been central to the development of biology in the twenty-first century.

Evolution, the unifying principle of biology and the process that explains the diversity of life on Earth, is based on variation in natural populations, the inheritance of genetic information from one generation to the next, and the selection of genetic types, through time, adapted to specific environments. We are no longer blind to processes that have created the patterns of diversity in the natural world that botanical illustrators have recorded for millennia. Moreover, evolutionary ideas have contributed to the way we think about living organisms, and to the re-evaluation of ourselves and our relationships with nature.

FOR SCIENCE TO progress, ideas and data must circulate and be exposed to the savage glare of criticism and testing. Illustrating a plant, giving it a name and placing it in a classification scheme do not mean we know anything about its biology. For example, multicoloured maize cobs have been drawn since the sixteenth century, but it was not until the twentieth century and the research of the North American geneticist Barbara McClintock that the origin and significance of these patterns began to be understood.[71]

New ideas may need new data, but sometimes all that is needed is for old data to be looked at through fresh eyes. A scientific idea that is correct, but not circulated and challenged, will eventually be discovered by someone. Raking up the idea from an archive might give its discoverer a good feeling, but the person whose name is associated with that idea is the one who published first. Darwin was acutely aware of this when he was faced with potential competition from Alfred Russel Wallace.

four

BLOOD AND TREASURE

> It would be quite lost labour to give any detailed account of this kind of scientific life, if it can be so-called, this dull occupation of plant-collectors.
>
> JULIUS VON SACHS, *History of Botany* (1890)[1]

For hundreds of generations, through cultural activities – synthesized into religions, traditions and mythologies – humans have explored, then recorded, interpreted, stored and transmitted, their observations of the natural world. Humanity's crops demonstrate that people manipulated and moved the biological world long before fifteenth-century Europeans were carried in ships beyond their horizons, across oceans, and out of the relative safety of coastal waters. These curious travellers and migrants – ranging from dreamers and slavers through merchants and farmers to aristocrats and refugees – disturbed centuries of European intellectual certainty. Yet within the velvet glove of discovery was hidden an iron fist of social, political and economic opportunism; chillies, potatoes and tomatoes transformed our diets, but tobacco, cocoa and sugar enslaved us.

In the early nineteenth century the French zoologist Georges Cuvier divided European natural historians into two groups: those, like him, who studied minutiae in the laboratory or library; and those engaged in the broad, 'cursory' practice of fieldwork.[2] At first sight, the experimental botanist Julius von Sachs's forthright dismissal of the 'labour' of plant collectors appears to be yet another volley in those periodic skirmishes that flare up among academics defending different agendas. However, Sachs's irritation was more deeply rooted in a perception that collectors missed opportunities to investigate fundamental scientific problems: '[They] did

Rosa leschenaultiana, a white-flowered, gland-covered climbing rose endemic to the Western Ghats, from Robert Wight's *Icones plantarum Indiae Orientalis* (1840). Rungiah, who worked for many botanists associated with the British East India Company, prepared the illustration, which was lithographed by Wight before being printed in Madras (now Chennai). The flowering shoot and fruiting cluster were drawn at natural size, while the other parts were 'more or less magnified'.[3]

some service to botany by searching the floras of Europe and of other quarters of the globe, but they left it to others to turn to scientific account the material which they collected.'[4]

Most specimens in the world's herbaria and botanic gardens have been collected by people who did not use them for research, who were 'intent only on determining what is immediately presented to the eye and making little enquiry into origin and affinities'.[5] However, these collectors unintentionally amassed raw material for future research, and, despite the slights, were rewarded for rare, well-prepared specimens and illustrations taken from exotic locations.[6] The efforts of field-based botanical collectors and

illustrators are not to be underestimated. Joseph Hooker regarded Robert Wight's six-volume *Icones plantarum Indiae Orientalis* (Illustrations of East Indian Plants, 1840–53) as an example of a 'remarkable instance of the perfection to which botanical illustrations can be brought by indomitable perseverance under the most discouraging circumstances'.[7]

Through a global tour, starting in the eastern Mediterranean, this chapter shows how the work of European botanical collectors has been complemented by illustrators in order to record patterns of global plant diversity. In the nineteenth century such patterns eventually led to the development of two ideas – Humboldtian biogeography and Darwinian evolution – that became fundamental concepts in modern biology.[8]

Collecting life

Bottling, boxing and pressing the natural world for scientific or private reasons is expensive, time-consuming and dangerous. Popular stereotypes of flower pressing as an activity to fill the spare time of children, genteel ladies and effete gentlemen are far removed from the reality of scientific fieldwork.[9] After five years' experience collecting tropical plants in coastal and central Brazil (1836–41), the Scottish surgeon-naturalist George Gardner wrote:

> [the] privations which the traveller experiences in these uninhabited, and often desert countries, can scarcely be appreciated by those who have never ventured into them, where he is exposed at times to a burning sun, at others to torrents of rain, such as are only to be witnessed within the tropics, separated for years from all civilized society, sleeping for months together in the open air, in all seasons, surrounded by beast of prey and hordes of more savage Indians, often obliged to carry a supply of water on horseback over the desert tracts, and not unfrequently passing two or three days without tasting solid food, not even a monkey coming in the way to satisfy the cravings of hunger.[10]

Twenty years later the Englishman Henry Walter Bates, having spent eleven years in the Amazon (1848–59), reflected, with typical understatement, on the physical and psychological strain of fieldwork:

> [I] suffered most inconvenience from the difficulty of getting news from the civilized world down river, from the irregularity of receipt of letters, parcels of books and periodicals, and towards the latter part of my residence from ill health arising from bad and insufficient food. The want of intellectual society, and of the varied excitement of European life, was also felt most acutely, and this, instead of becoming deadened by time, increased until it became almost insupportable. I was obliged, at last, to come to the conclusion that the contemplation of Nature alone is not sufficient to fill the human heart and mind . . . Towards the end of this time my clothes had worn to rags; I was barefoot, a great inconvenience in tropical forests . . . my servant ran away, and I was robbed of nearly all my copper money.[11]

Collectors have as many guises as there are motivations for collecting. There are those for whom plants are merely another spoil of adventure; some are interested in personal fame and fortune, while others are enthused by the sheer delight of collecting or making scientific contributions. Expeditions are financed by personal fortunes, the generosity of private sponsors or institutions, the sale of specimens, or the munificence of governments. Explorers travel individually, or as members of ad hoc expeditions or commissioned enterprises.

Both Gardner and Bates worked with little funding, tiny field teams and only essential equipment. Few plant collectors travelled in a manner worthy of the imperial stereotype. With governmental largesse, one such was Joseph Hooker, who enumerated the membership of his eastern Nepalese 56-strong expedition team in 1848 as:

> myself, and one personal servant, a Portuguese half-caste, who undertook all offices, and spared me the usual train of Hindoo and Mahometan servants. My tent . . . instruments, bed, box of clothes, books and papers, required a man for each. Seven more carried my papers for drying plants, and other scientific stores. The Nepalese guard had two coolies of their own. My interpreter, the coolie Sirdar (or headman), and my chief plant collector (a Lepcha), had a man each. Mr Hodgson's

> bird and animal shooter, collector, and stuffer, with their ammunition and indispensables, had four more; there were besides, three Lepcha lads to climb trees and change the plant-papers, who had long been in my service in that capacity; and the party was completed by fourteen Bhotan coolies laden with food, consisting chiefly of rice with ghee, oil, capsicums, salt, and flour. I carried myself a small barometer, a large knife and digger for plants, note-book, telescope, compass, and other instruments; whilst two or three Lepcha lads who accompanied me as satellites, carried a botanising box, thermometers, sextant and artificial horizon, measuring-tape, azimuth compass and stand, geological hammer, bottles and boxes for insects, sketch-book, &c, arranged in compartments of strong canvass bags . . . Other sepoys were distributed amongst the remainder of the party; one went ahead to prepare camping-ground, and one brought up the rear.[12]

The rewards for Hooker were the plaudits of nations, while Bates was recognized by few during his lifetime, despite later being associated with an important evolutionary concept: Batesian mimicry. Most botanical collectors, though, are like Gardner – footnotes to the deeds of others.

The scientific success of the *Endeavour* voyage made Joseph Banks's name and helped him to stimulate the interest of late eighteenth-century British society in botany.[13] Moreover, his experiences showed him that for scientific purposes, hurried observations by itinerant travellers were no substitute for careful observations made by naturalists living in a particular area. Such observers could study plants through all seasons and phases of their life cycle. Consequently, Banks established his own global network of professional plant collectors, the first of whom was the Scottish gardener Francis Masson.[14]

The greatest risks associated with botanical exploration – travel, illness and the weather – have not changed. Those who returned to Europe frequently published travelogues, so visitors to foreign lands had no dearth of advice about what to expect. Indeed, the problem was often separating tall tales, or personal observations tainted by political, social or religious prejudices, from facts. In the early nineteenth century Banks impressed

upon two young English plant collectors (Allan Cunningham and James Bowie) whom he sent to Brazil that they were 'by no means to presume on the vigour of your youth and the [strength] of your constitution but diligently conform yourselves to the practice of the Natives in avoiding the dangers of the Climate and the hazard of visiting unhealthy districts'.[15]

Initially, as a naive traveller in the tropics, Gardner misjudged the brevity of dusk, and miscalculated the importance of the wet and dry seasons and the strength of the sun, despite having been warned that 'some deaths occur from the carelessness of Europeans in exposing themselves to the vertical rays of the sun.'[16] Rejecting guidance that wine or brandy always be mixed with water, he stated that these substances 'were unnecessary, but decidedly hurtful to those whose occupations lead them much into the sun'.[17] In contrast to Gardner's austerity, Richard Francis Burton's advice, three decades later, was to the 'comfortable traveller': 'let no weak regard for sex or age deter you from taking, or at least trying to take, the strongest beast, the best room, the superior cut, the last glass of sherry.'[18]

Despite such precautions, knowledge of the world's botanical treasury has been purchased with the blood of generations. At least five of Linnaeus's most prominent students 'perished in the Cause of Science': Pehr Löfling in Venezuela; Fredrik Hasselquist in Turkey; Pehr Forsskål in Yemen; Carl Fredrik Adler in Java; and Christopher Tärnström in Vietnam.[19] Banks's expedition on the *Endeavour* killed all but two of the nine men he took with him, while, in Hawaii, David Douglas perished in a bull pit.[20]

Our present-day legal and ethical concerns rarely inconvenienced naturalists of the past, who rather believed the natural world was common heritage.[21] Today, such actions – denying the rights of people to determine what happens in their own countries and to the botanical knowledge they have acquired over generations – are reprehensible. Moreover, scientific collecting expeditions, spanning years, that meander across continents have become impossible.

Field-based naturalists soon discovered that fieldwork is the art of the possible, where responsiveness, resilience and resourcefulness are essential. They recorded their first impressions, evidence and ideas in notebooks filled with jottings and sketches. Before the mid-twentieth century, naturalists may have had rudimentary training in the fundamentals of drawing and

painting; some, such as Joseph Hooker, were highly skilled. Today, sketches in pencil, pigment and ink often give way to pixels in the digital camera.

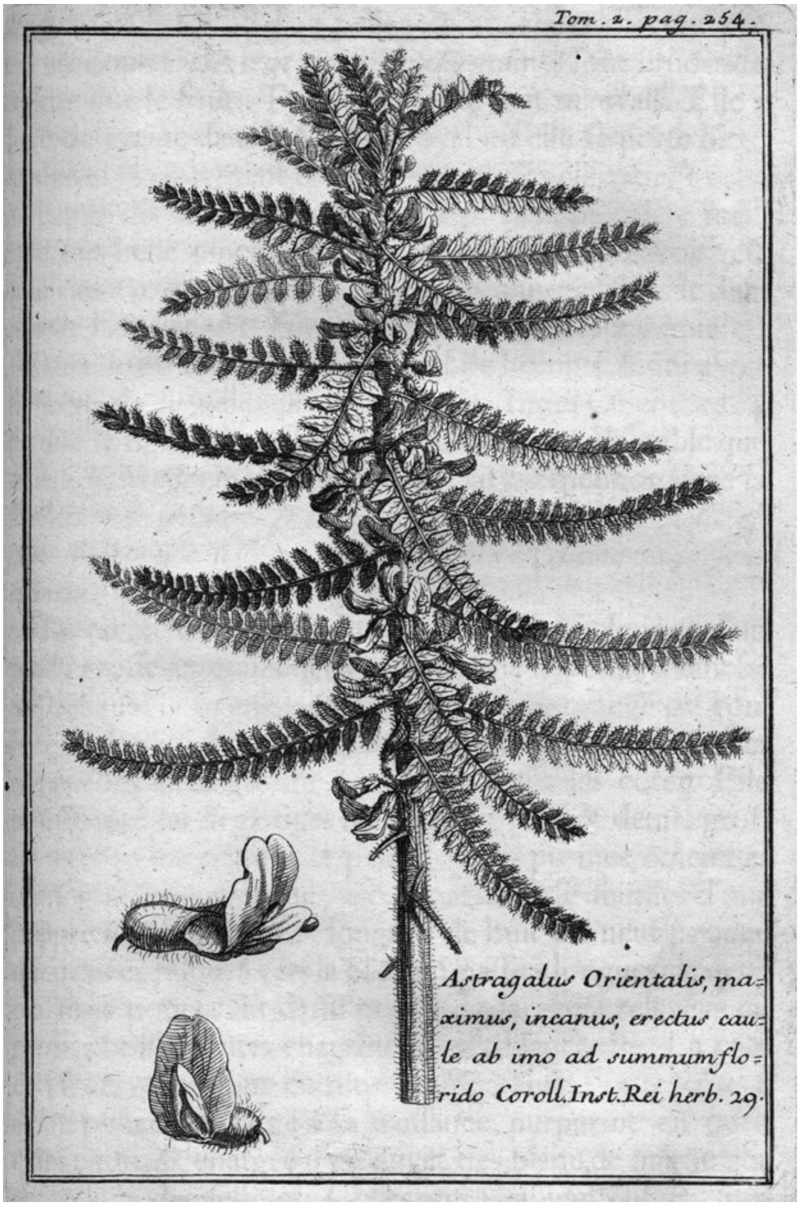
Good fortune

Between 1700 and 1702, Joseph Pitton de Tournefort explored the eastern Mediterranean and the Caucasus – the western fringe of the Ottoman Empire. The French monarch had charged him 'to make diligent Search after things relating to Natural History . . . the several Distempers and Medicaments in those Countries [and] . . . compare the Antient Geography with the Modern'.[22] Tournefort's plan was more grandiose: 'to collect every thing in general that was worthy [of] his Attention in all kinds of Sciences, or which might any ways serve to enrich the Study of Physick and the Commonwealth of Learning'.[23]

When appointed professor of botany at the Jardin du Roi, Paris, in 1683, Tournefort – although only 27 – was already an experienced field botanist, having explored the areas around Montpellier and through the Pyrenees and the Iberian Peninsula.[24] Consequently, he knew planning was important if an expedition were not to become an adventure. Tournefort recognized that in addition to weather, disease and local people, having the right team was essential to his success:

> I wanted a couple of staunch Men that could be depended upon, and who were of a humour to share with me the Inconveniences inseparable from long Journeys. Nothing is so dismal, as to fall sick in a Country where one knows no body, and where Physick is unknown. It frets a Man too, to see fine Objects, and not be able to take Draughts of them; for without this help of *Drawing*, 'tis impossible any Account thereof should be perfectly intelligible.[25]

He had the 'singular good fortune' to find Andreas von Gundelsheimer, an 'excellent Physician' with 'an extreme passion for Natural History', and the botanical illustrator Claude Aubriet, who was 'no less industrious than skilful in painting . . . and accordingly his Ability has merited him the Place of *Painter of the King's Closet*'.[26] One judgement of history is that 'Aubriet's



Copperplate engraving of an illustration made by Claude Aubriet in 1701 as he explored northeastern Turkey with Joseph Pitton de Tournefort and Andreas von Gundelsheimer, and published in Tournefort's *Relation d'un voyage du Levant* (A Voyage in the Levant, 1717). After an evening of collecting, Tournefort claimed enthusiastically: 'Can any thing be more charming than *Astragalus*, two foot high, laden with Flowers quite from the bottom to the top of the Stalks?'[27] He went on to name it 'Astragalus Orientalis, maximus, incanus, erectus caule ab imo ad summum florido' (Largest Oriental astragalus with grey, erect stem and flowering from bottom to top). In 1753 Linnaeus used Aubriet's image and Tournefort's description to give the plant its modern scientific name, *Astragalus christianus*, one member of a very large genus of legumes.

drawings, made under Tournefort's supervision, from life, are very exact and leave little to be desired.'[28] Moreover, Tournefort regarded Gundelsheimer and Aubriet as 'real Friends' – despite undertaking two years of arduous fieldwork in their company.[29]

Setting sail from Marseilles in the Mediterranean spring, the group explored Crete for three months before visiting more than thirty islands scattered across the Aegean Sea. After passing through the Dardanelles

and staying in Constantinople (now Istanbul), they trekked along the southern coast of the Black Sea into Armenia and Georgia. Their return, overland through central Turkey via Ankara and Bursa, took them to İzmir, then by boat across the Mediterranean to southern France. Along the way, the team discovered hundreds of new species and collected thousands of herbarium specimens, sometimes to the bemusement of those with whom they travelled. For example, one night in mid-June 1701, travelling with a merchant caravan at a village east of Bayburt in northeastern Turkey, by moonlight, they 'omitted not to fill our Bags, our Merchants laughing all the while, to see us three groping in a Country dry and burnt up in appearance, but notwithstanding enrich'd with very fine Plants. When it was Morning, we review'd our Harvest, and found ourselves rich enough.'[30] Moreover, Aubriet made hundreds of partially completed paintings and sketches, on which he wrote the names of colours.[31] As they travelled, the team suffered a problem familiar to peripatetic collectors and illustrators: satisfying the expectations of remote patrons who have little appreciation of the difficulties of collecting or illustrating plants in the field.[32]

Once back in Paris, Tournefort published a list of names of the plants his team had discovered, while Aubriet turned sketches into finished illustrations. Some of those illustrations were published in Tournefort's work – 'Illustrated with Full Descriptions and Curious Copper-Plates of great Numbers of Uncommon Plants'.[33] Others were published in René Louiche Desfontaines's *Choix de plantes du corollaire des instituts de Tournefort* (Choice Plants from a Supplement to Tournefort's System, 1808) and Hippolyte François Jaubert and Édouard Spach's five-volume *Illustrationes plantarum orientalium* (Illustrations of Oriental Plants, 1842–57).[34] Aubriet's images remained the most important illustrations of eastern Mediterranean, Turkish and Caucasian plants for more than a century, and their publication and deposition in a public collection meant that his work was accessible to other botanists after his death.

The same cannot be said of the illustrations Ferdinand Bauer made during John Sibthorp's twenty-month expedition to the eastern Mediterranean.[35] Independent wealth and his academic position at the University of Oxford released Sibthorp from the burden of capricious sponsors. Duplicates of Tournefort's specimens were already in the university's herbarium. Moreover, Sibthorp had the freedom to move where he wished,

Watercolour (opposite) of the rare, southwestern Turkish *Fritillaria sibthorpiana* by Ferdinand Bauer, based on pencil sketches (right) he made in the field in the spring of 1787 and herbarium specimens (left) collected by the Scottish military engineer Ninian Imrie. Until the species was rediscovered by two Scandinavian botanists in 1972, it was known only from Imrie's specimens and Bauer's watercolour, which was published in John Sibthorp and James Edward Smith's *Flora Graeca* (1823).

subject to the usual limitations of climate, seasonality and personal security. The experiences of such travellers as Tournefort meant he could minimize likely encounters with plague, bandits and pirates, but other risks, including short flowering seasons and the weather, were outside his control. Despite the information he had, planning was not a priority for the self-confident Sibthorp with illustrator Ferdinand Bauer commenting that: 'I think Dr Sibthorp will beging [begin] His tour quite in the old style never come to a determination before the last day, then at ones all in haste which is most unblessant.'[36]

Sibthorp met Bauer in Vienna, where he acknowledged the illustrator's exceptional talent as 'superior to any Artist I have yet seen'; 'my Painter in each part of Natural History is Princeps pictorum he joins to the Taste of the Painter, the Knowledge of a Naturalist[,] & Animal, Plant & Fossil touched by his Hand shew the Master.'[37] Bauer accompanied Sibthorp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throughout his journey and returned with him to Oxford, but over the many years of their professional association, their personal relationship disintegrated into mutual recrimination. Another man picked by Sibthorp to join them for part of the journey, the English mine owner and Hellenophile John Hawkins, became their go-between. Ultimately, both Bauer and Hawkins proved essential to Sibthorp's scientific and personal legacies.

Sibthorp was explicit about his motivations for travel:

> this is the part of my Voyage on which I form my greatest Expectations from whence I hope will flow a future Source of Fame . . . Many Discoveries are still to be made for the Natural History of these Countries if not imperfectly known. The figures of [Johann Christian] Buxbaum are ill executed[;] they are no more reconnoissable. The Superiority of my Draughtsman will fence me what I shall publish from risking a similar Fate & will entitle me to a Place in the Petersburg or in our Academy with just Pretensions.[38]

Throughout their journey, Sibthorp collected plants and made partial notes, while Bauer sketched plants, recording colours using his numbering system. Botanical fieldwork is exciting, sometimes dramatic and often stressful, but it is the completion of monotonous chores that makes it successful. Among such routine and essential tasks are pressing specimens, ensuring they are properly dried and labelling everything. Sibthorp labelled neither specimens nor sketches, trusting to his memory, a habit that caused major problems for those charged with piecing together his scientific legacy following his premature death.

When Sibthorp and Bauer arrived back in Oxford, in late 1787, they had thousands of herbarium specimens and hundreds of pages of field sketches and notes in hand. Bauer spent the next five years turning his sketches into some of the finest botanical watercolours ever made. Sibthorp started to order his specimens and notes, but published nothing. Bauer's watercolours have been lauded since the mid-nineteenth century, but, even with the publication of Sibthorp and Smith's extremely rare *Flora Graeca* (1806–40), their contribution to our scientific knowledge of Mediterranean botany has been limited.

Soil torn up by volcanoes

On his way to the Americas from Spain in 1799, Alexander von Humboldt made a brief visit to Tenerife, in the Canary Islands archipelago: 'it would have been very painful to naturalists, to have seen the coast of Teneriffe, without having been able to tread a soil torn up by volcanoes.'[39] Here he saw, and speculated upon, the age of a huge dragon tree, a species endemic to Macaronesia, growing in the gardens of Juan Domingo de Franchi at La Orotava on the north coast of the island.[40]

When the popular account of Humboldt's American expedition was published, a copperplate engraving by Louis Bouquet of this plant was included.[41] The model was a drawing by Pierre Antoine Marchais, which in turn was based on Pierre Ozanne's sketch made in 1776 – when Humboldt was only seven years old. In 1819 this dragon tree lost half its crown during a storm, then 'certain Goths hacked an immense piece out of the thin wall of hollow trunk, for the Museum of Botany at Kew,' before it was finally destroyed in 1867.[42] In the nineteenth century the romance associated with the tree's presumed age and size made it an attraction for the droves of naturalists and artist-travellers, such as Maria Graham, who visited the archipelago.[43]

Wood engraving of the great dragon tree of Orotava, Tenerife, made in 1872 by the illustrator and archaeologist Worthington George Smith from a photograph taken by the Italian horticulturalist Emanuele Orazio Fenzi. Symmetrical young dragon trees, depicted in the background, emphasize both the effect of a storm in 1819 that destroyed half of the great dragon tree's crown, and its great age.

Today, since the Orotava dragon tree – an 'asparagus stalk, with a remarkable power of vitality, and an equally eminent slowness of growth' – is known only from visitors' illustrations, we must make our own judgements about the veracity of these images.[44] However, even in the mid-nineteenth century doubts were raised – especially by early photographers – about the bias that expectations, technical skill and artistic cultures introduced into images of the plant.

The Italian-born British astronomer Charles Piazzi Smyth and his wife, Jessica Duncan, who made remarkable stereophotographs of Tenerife, summarized these concerns most forthrightly:

Hand-coloured engraving of the Iberian mignonette species *Reseda undata*, based on an illustration by Jean-Christophe Heyland from Pierre Edmond Boissier's *Voyage botanique dans le midi de l'Espagne* (1839). Heyland worked under Boissier's direction and, 'thanks especially to the deep feeling of nature which characterizes this distinguished artist, these figures reached a remarkable perfection, although made from desiccated plants, with the exception of a small number drawn from living and reared samples of my [Boissier's] seeds.'[45]

errors are always copied, and magnified as they go; seldom are excellences reproduced. After a few removes, the alleged portrait of nature, is only a caricature of the idiosyncrasies of the first artist . . . Artists, landing for a few hours from a ship, were appalled at the tangled mass of vegetation about the old dragonier, and made a sort of ideal tree, on a bare level surface. Nature, on the other hand, awed by nothing she has made, takes on the collodion plate, the whole scene, with all

> its foreshortenings, all its groupings, as instantaneously as a flat wall . . . the hollow trunk, the wrinkled bark, the gardener's scaffolding, which has passed into the fiction of the ladder and man; the long branches, the sword-shaped terminal leaves, hedges and terraced land, distant trees and still more distant hills.[46]

The editor of the *Gardeners' Chronicle* drew attention to perceived problems with mid-nineteenth-century photographs – stability and circulation – when a wood engraving of the Orotava dragon tree was published in 1872: 'it is specially desirable that a good engraving be issued, as Professor Smyth's photographs have sadly faded, and Signor [Emanuele] Fenzi's large photograph, from which our sketch was taken, is in few hands.'[47]

The Canary Islands are attractive for reasons other than ancient dragon trees; they belong to a global hotspot of plant diversity. Seventeenth- and eighteenth-century naturalists, including James Cuninghame and Francis Masson, sent back to Europe plants that were found nowhere else.[48] Moreover, as more naturalists searched the archipelago, more unusual plants and animals were discovered, encouraging more people to explore. One naturalist, Charles Darwin – who dreamed of visiting, having read of Humboldt's journey to Teide, the peak at the heart of Tenerife – was in 1832 prevented by bureaucracy from doing so.[49]

The most significant nineteenth-century explorers of Canarian natural history were Philip Barker Webb and Sabin Berthelot, who collected vast numbers of herbarium specimens.[50] Their three-volume *Histoire naturelle des Iles Canaries* (Natural History of the Canary Islands, 1836–50), with its 252 engraved botanical plates, has been described as the 'only one in which descriptions and illustrations of Canarian plants are provided in sufficient detail for identification'.[51] One of the primary illustrators who transformed Webb and Berthelot's botanical specimens was the German hairdresser-turned-engraver and illustrator Jean-Christophe Heyland, who lived and worked in Switzerland for more than 60 years. During a nearly quarter-century-long association with the Swiss botanist Augustin Pyramus de Candolle, Heyland contributed to the botanical legacies of many nineteenth-century botanists. For example, he made the illustrations for the 181 hand-coloured, engraved plates of Pierre Edmond Boissier's two-volume *Voyage botanique dans le midi de l'Espagne* (Botanical Journey in Southern Spain,

1839–45), prepared nearly two hundred black-and-white engravings for the final two volumes of Jules Paul Benjamin Delessert's five-volume *Icones selectae plantarum* (Illustrations of Selected Plants, 1820–46) and produced 122 black-and-white lithographs for Boissier's *Icones euphorbiarum* (Illustrations of the Genus *Euphorbia*, 1866).

Every lover of nature

In 1805 a 24-year-old artist-naturalist named William Burchell arrived in the mid-Atlantic Ocean island of St Helena with mercantile ambitions. However, he soon became bored, so he became the island's resident botanist.[52] Five years later he left for Cape Town, where he began planning an expedition through South Africa. As a collector, Burchell was tied to neither employer nor learned society, and he took full advantage of this freedom 'to extend his researches to whatever appeared likely to afford interesting information . . . in a country still in a state of nature, and where art has done so little, the works of the creation, ever delightful to all but those of a corrupt and depraved mind, necessarily present themselves the most frequently to notice.'[53]

Hand-coloured engraved plate of *Stapelia pulvinata* from the plant collector Francis Masson's *Stapeliae novae* (New Stapelias, 1796). Before Masson's exploration of South Africa in the 1770s and 1780s, only two carrion-flower species were known to European botanists. In this work, Masson describes dozens of new species. However, today's botanists would include the plant illustrated on this plate within the range of variation of a species known in Masson's time, *S. hirsuta*.

Hand-coloured engraving of the South African member of the coffee family, wild pomegranate. The plant was known to botanists long before it was formally described by Robert Brown in 1820. Brown, 'with that liberality and vigilance which he extends to every interest of science, availed himself of the appropriate occasion of honouring the merits of Mr [William] Burchell, the zealous and enterprising investigator of the regions to which our plant belongs'.[54] The drawing made by M. Hart from a specimen growing at the nursery of Messrs Colville in the King's Road, Chelsea, was engraved by J. Watts and printed as a hand-coloured gatefold plate.

To explore 'regions never before trodden by European foot', Burchell created his own mobile collecting facility – a purpose-built waggon equipped with all he could imagine necessary for the artist-naturalist inquisitive about, and acquisitive of, everything Africa had to offer.[55] His equipment and provisions included 'goods as presents to the chiefs, and for bartering with the natives . . . a chest of select medicines . . . a large assortment of stationary [*sic*], and every requisite for drawing in water and body-colours; together with prepared canvas, and the articles used for painting in oil'.[56]

Even with such preparations, Burchell was not immune to irritations when sketching. On one occasion he was

> unable to find a single yard of ground that did not swarm with large black ants. It was, therefore, impossible to sit down, and nearly so, to stand; for these troublesome insects, ever on the search for something to eat, soon found their way over my shoe, and seemed uncommonly delighted at feasting on a white-man's leg, a treat most likely, till now, quite unknown to the little tribe, and, in spite of all my endeavours, they were determined not to let go their prize.[57]

Burchell left Cape Town in June 1811 and, between then and August 1815, travelled approximately 7,000 kilometres (4,350 miles) through South Africa. His route was a rough triangle extending from Cape Town in the Western Cape, northeast beyond the Orange River to Griekwastad, Kuruman and Heuningvlei in the Northern Cape, then southeast to Port Alfred in the Eastern Cape, before returning to Cape Town.[58] During his journeys Burchell claimed he had 'no companion or assistant', but he finesses the contributions of others by adding that he had no 'other attendants than

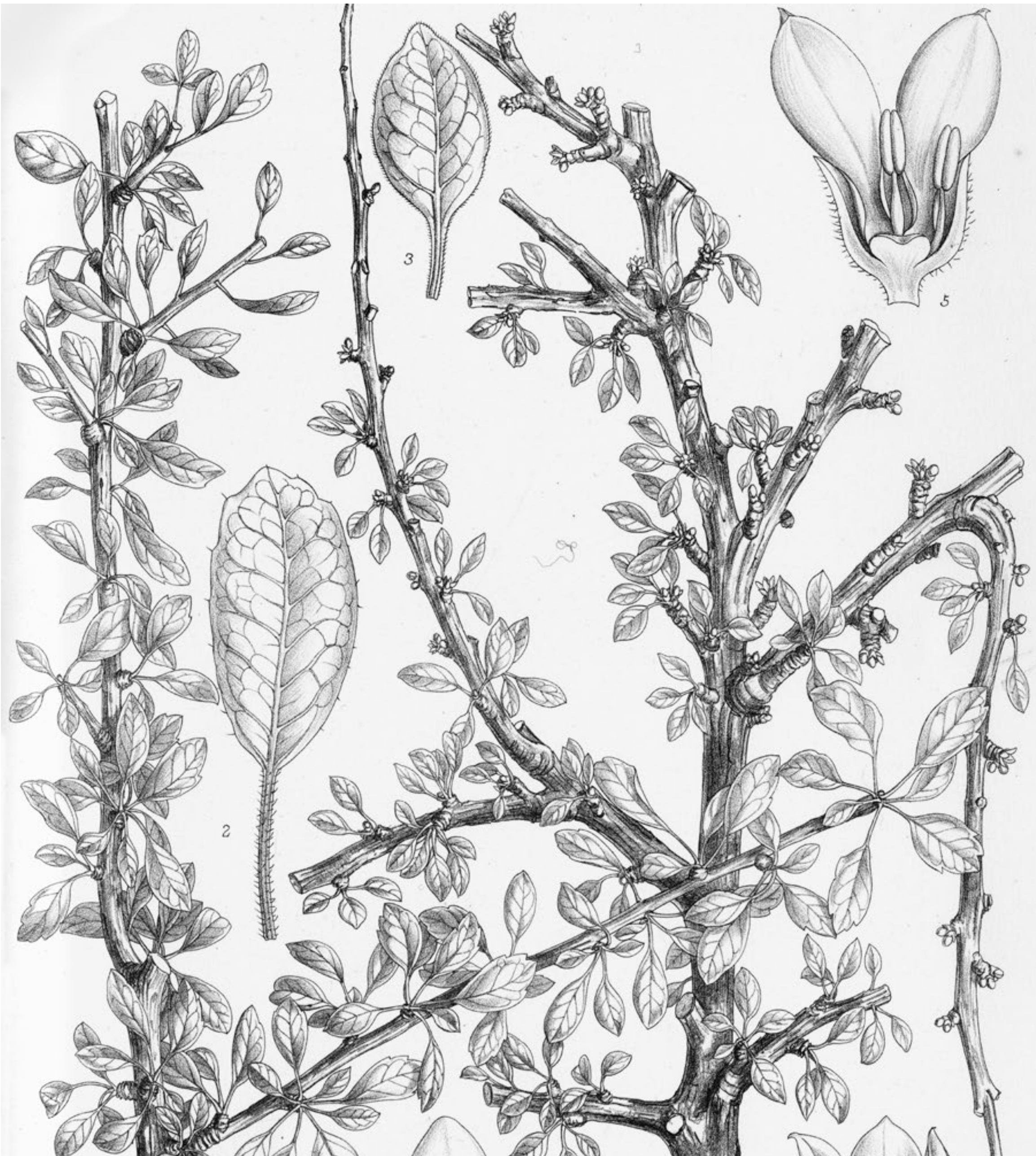
Illustration and partially hand-coloured lithograph of the South African living stone, *Lithops hookeri*, by Walter Hood Fitch for *Curtis's Botanical Magazine*, showing the plant's habit, together with leaf and flower details. The generic name means 'stone-like', and was adopted in 1922. In September 1811, in South Africa's Northern Cape Province, William Burchell had observed the 'curiously shaped pebble'.[59] Rudolf Marloth was surprised when pebbles on a rock-strewn South African path began 'bearing yellow flowers, one at the top of each stonelet'.[60]

a few Hottentots, the number of whom never exceeded ten'.[61] Over 50,000 'collections in Natural History were made, and a multitude of objects hitherto unknown to science brought to England', which included 'about five hundred drawings, the subjects of which are landscapes, portraits, costume, zoology, botany, and a variety of other objects'.[62]

Burchell was a prolific collector. Despite being his own master, he was aware of how limited his time was given the vast range of his interests, combined with the distances over which he chose to travel. For example, on 14 September 1811 he picked up from stony ground in the Western Cape what he believed to be 'a curiously shaped pebble, it proved to be a plant . . . but in colour and appearance bore the closest resemblance to the stones, between which it was growing . . . this juicy little [plant] . . . may generally escape the notice of cattle and wild animals.'[63] Regarding such succulents, Burchell regretted that he 'had neither opportunity for preserving them, nor time for making drawings'.[64] He went on to recommend that

> an object very desirable for botany, would be obtained, if a good draughtsman were to pass three or four years in travelling about the Cape colony, with the sole view of drawing, on their native spot, all those plants . . . which, from their fleshy nature or delicate substance, cannot well be preserved in an herbarium. He would, by doing this, accomplish a work of great utility, and one which, from the singular forms, or the delicate and beautiful flowers of the objects, could not fail to interest every lover of nature.[65]

On leaving South Africa, Burchell explored Brazil before returning to Britain. There he spent decades sorting thousands of herbarium specimens and drawings, although very few of his discoveries and illustrations were published. Moreover, 'unfortunately for science, Dr Burchell never published, and scarcely allowed any naturalist access to his Herbarium. On his death . . . his magnificent botanical collections were presented to Kew.'[66] Consequently, during his lifetime his contribution to the study of plants in St Helena, South Africa and Brazil was overlooked.[67] Burchell was defeated by his own enthusiasm for fieldwork. He had collected so much that he could never hope to sort, identify and publish all of it – even though he lived into his eighties.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Habit and habitat of the Socotran dragon's-blood tree based on a sketch by Lieutenant Charles James Cockburn, who accompanied Isaac Bayley Balfour on his hastily organized exploration of Socotra in 1880. This species was formally described from specimens collected on this expedition, despite the resin having been exported for centuries. Wounds shown on the plant's trunks are probably from resin tapping. Lithograph by John Nugent Fitch.

Island of incense and dragon's blood

Geological isolation, combined with extreme temperatures and low rainfall, has contributed to the evolution of an endemic flora on the politically Arabian, but geographically African, island of Socotra that includes uniquely shaped trees and succulents. Since antiquity, the island has been known as the source of medicinal aloes, dragon's blood – a resin used in dyes and varnishes – and aromatic gums used in incense.[68]

Short periods of focused fieldwork may be highly productive, even when planned in haste. Few full-scale botanical expeditions to poorly known locations have been planned with the rapidity of the Scottish botanist Isaac Bayley Balfour's exploration of Socotra in 1880. On 20 December

Lithograph of the Socotran endemic shrub and resin-producing myrrh relative *Commiphora socotrana*. The species varies from being an unarmed tree 10 metres (33 ft) tall in forested areas to a small, spiny shrub on desert sites. Harriet Anne Thiselton-Dyer's illustration, made from specimens collected by Isaac Bayley Balfour, shows some of the variation in leaf arrangement and form, together with floral details. Lithograph by John Nugent Fitch.

1879 Balfour was asked by Joseph Hooker, on behalf of the British Association for the Advancement of Science, to lead an expedition to investigate the natural history of the island. Balfour left Britain twenty days later, and 'many things which under more leisurely conditions would have been done had to be left undone.'[69] By 11 February 1880 he was in Socotra, and by the end of March he had left the island. He was there for just 48 days.

Balfour left Britain in the company of Alexander Scott, a gardener at the Royal Botanic Garden, Edinburgh. In Aden, he was joined by the soldier Charles James Cockburn, of whom Balfour wrote, 'apart from the advantage and pleasure I derived from having him as a companion, the excellent sketches he made will enable the Committee to judge of how great an acquisition he was to the staff of the expedition and of the valuable services he rendered.'[70] On their arrival in Socotra, a canny Balfour was 'occupied in obtaining stores and servants; the latter not easy to procure, especially a good interpreter, on account of the very high rate'.[71]

On the island, the team made collections of natural history objects of all sorts, but naturally paid special attention to plants. Given their economic value, historical interest and curious distribution, living examples of the dragon's-blood tree and the Socotran aloe were returned to Edinburgh, with 'dried specimens of between 500 and 600 species of flowering plants ... besides some Cryptogams [ferns]'.[72] The trip precipitated many natural-history expeditions to Socotra, which have continued to the present day.

Balfour offered his own advice for future travellers in Socotra:

> a rich harvest awaits any collector who may visit the island ... [but] it would be well if the date of its arrival were timed so that it should have the last months of one and the first months of the following year upon the island. Our expedition reached the island too late in the year, so that before we left the heat was so intense as to prevent our doing so much work as we desired.[73]

Sibthorp suffered similar problems, and was frustrated by sea crossings that prevented him from collecting plants during their brief flowering in the Mediterranean spring of 1787.[74]

Eight years after returning to Edinburgh, Balfour finally published his botanical results. The 'often fragmentary' specimens he, Scott and

Cockburn had collected were turned into one hundred black-and-white lithographs by Matilda Smith, Harriet Anne Thiselton-Dyer and John Nugent Fitch.[75] Today, more than eight hundred plant species are known from Socotra; over one third of these are found nowhere else on Earth.[76] When Balfour started his expedition, only one plant species on Socotra was known with certainty to Western science: the Socotran aloe. The sap of the dragon's-blood tree, which Balfour formally described and Cockburn sketched, had been exported by indigenous Socotrans for centuries. We now think the dense, umbrella-shaped crowns of this tree collect water from fog and channel it along the leaves, branches and trunk to the soil. Under the canopy, the ground is relatively moist, creating a microclimate that is important for the evolution and survival of many endemic Socotran plants.[77]

Detectors of rare plants

By the time mid-seventeenth-century European explorers had found the New Zealand archipelago, descendants of Polynesian settlers had been living on the islands for at least four hundred years. One naturalist claimed that scientific botanical knowledge 'fell naturally and conveniently into two periods': before and after the signing in 1840 of the Treaty of Waitangi.[78]

Naturalists of the first period, dominated by those who accompanied English, French and American naval expeditions exploring the southwestern Pacific Ocean, naturally accumulated knowledge about coastal plants. For six months, on their way to Australia with Captain Cook, Joseph Banks and his team collected and drew hundreds of New Zealand's plants.[79] Yet, despite being prepared for publication, the illustrations were never brought out. Banks's knowledge of New Zealand's unique flora, which languished among his private papers, included a familiar garden plant, *kōwhai ngutukākā* (lobster claw), an evergreen, shrubby legume with slender, spur-like wine-coloured flowers – 'one of the most beautiful plants known'.[80] This species, native to only small areas of the North Island, was introduced into European horticulture in 1831, although its ornamental value was recognized by the Māori long before Cook's arrival.[81]


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Hand-coloured engraving by Joseph Swan of a specimen of the New Zealand legume *kōwhai ngutu-kākā* that flowered in Edinburgh Botanic Garden in 1837. Walter Hood Fitch's original illustration has an unusual composition. The floral details are obscured by leaves, a fact that is at odds with the text, which focuses on flowers and the meaning of the plant's generic name, *Clianthus* – 'glorious flower'.

The second period was dominated by collectors, mainly English settlers, using the advantage of residency to venture inland from the coast. When Joseph Hooker arrived at the Bay of Islands, in the north of the North Island, during James Clark Ross's Antarctic Expedition in August 1841, he was intent on recording new species and their distributions. However, 'collections made at the Bay of Islands . . . contained no novelty among flowering plants, not known to Mr [William] Colenso and Dr [Andrew] Sinclair, with whom I spent many happy days.'[82] At St Helena, earlier in the voyage, Hooker had written to his father, William Jackson Hooker, the newly appointed director of Kew, about his collecting activities: 'I can hardly expect you to be much pleased with them, though I assure you I never spent an idle day ashore.'[83] More acutely, in the narrow, competitive world of species discovery, the English naturalist Hugh Cuming had made a 'much more brilliant collection' before Hooker arrived in St Helena.[84] Should these collections contain new species, Cuming might describe

Olearia colensoi, a leathery-leaved daisy bush endemic to New Zealand, was first collected from subalpine thickets on Mt Hikurangi, the North Island's highest non-volcanic peak, by a Māori paid to harvest plants for William Colenso. The species, which honours Colenso in its name, was formally described by Joseph Dalton Hooker in his account of the plants of New Zealand. Hand-coloured lithograph by Walter Hood Fitch from Hooker's *The Botany of the Antarctic Voyage of HM Discovery Ships Erebus and Terror* (1853).

Adams's mistletoe is an extinct species that was endemic to the North Island of New Zealand. It was last recorded in 1954 by the New Zealand botanical illustrator Audrey Eagle. This mistletoe, which was probably first collected in 1867 and formally described in 1880, commemorates the New Zealand plant collector James Adams. Lithography by John Nugent Fitch, based on illustrations by Matilda Smith, from Thomas Cheeseman's *Illustrations of the New Zealand Flora* (1914).

them first – detracting from Hooker's ambitions to become a professional botanist. Thus was the context within which Hooker worked.

Returning to London in 1843, Hooker began publication of his six-volume *Flora Antarctica* (1843–59), which covered more than 3,000 species, of which approximately a third were illustrated with hand-coloured lithographs. He underlined his appreciation of Colenso and Sinclair by including them in the dedication of the volumes on New Zealand plants: 'this work, which owes so much to their indefatigable exertions, is dedicated by their very sincere friend.'[85] Indeed, Colenso is mentioned more frequently than any other botanist in the account as one of the 'detectors of rare plants in new or remarkable localities'.[86]

Colenso, a Cornish missionary printer who had settled in the North Island in 1834, was interested in natural history.[87] On Christmas Day 1835 he may have fleetingly met Charles Darwin, but it was his prolonged

excursions in 1838 in the company of Allan Cunningham – who had been sent to Brazil and then Australia by Joseph Banks – that consolidated Colenso's skill as a plant collector. Colenso was eventually ordained. As he travelled and proselytized across much of the North Island, he also botanized, gaining a reputation as a fiery, headstrong, hypocritical preacher but a highly skilled botanist. Colenso corresponded with Hooker for the rest of his life, regularly dispatching cases of herbarium specimens to Kew. However, when the 'colonial' presumed to be anything other than a supplier of specimens, Hooker was quick to assert his authority as the professional in the relationship.[88]

Colenso was the most prominent of numerous resident collectors who, together with botanical illustrators based in New Zealand, contributed to European knowledge of New Zealand plants during the nineteenth century.[89] Another was the Anglo-Irish teacher James Adams, who cultivated a productive relationship with the professional naturalist Thomas Cheeseman at the Auckland Museum.[90] Among the many plants Adams discovered is the now extinct mistletoe that bears his name: *Trilepidea adamsii*.[91] His great-granddaughter was the prominent New Zealand botanical illustrator and museum curator Jacqueline Nancy Mary Adams.

By the end of the century, in the opinion of Cheeseman, the study of New Zealand's plants was being stifled by the absence of a comprehensive, illustrated Flora.[92] Cheeseman eventually filled the gap, but he resorted to the skill of Matilda Smith at Kew:

> it would have been a satisfaction . . . if there had been some competent botanical artist resident in New Zealand to whom the work could have been entrusted, but no person possessing the necessary qualifications could be found. Nor is this at all surprising, for botanical drawing, together with a knowledge of how to prepare the microscopical analyses required, is an art in itself; and the number of good botanical artists in England even is small.[93]

Bark and rubber

One risk of exploration is transporting, or encountering, diseases that kill or debilitate, such as mosquito-borne ague, better known as malaria. Early seventeenth-century Europeans realized that bitter extracts from the bark of a Peruvian tree – the fever tree – cured malaria, but they knew little about the tree or the processes of harvesting its bark and extracting the curative chemicals. This vacuum of ignorance soon became populated with all manner of trader, physician and charlatan vying for profit in the marketplace of healing hope. The only supplies of raw bark were from Spanish South America – the Viceroyalty of New Granada (present-day Colombia, Ecuador, Venezuela and Panama) and the Viceroyalty of Peru (including today's Peru and Chile).[94] Yet botanical ignorance meant there was no understanding that several species of fever tree, with differing properties, inhabit the various parts of the Andes.

In 1777 Charles III of Spain authorized the first Royal Expedition (1777–88) to explore the natural history of the Viceroyalty of Peru. It was led by two relatively inexperienced Spanish botanists, Hipólito Ruiz López and José Antonio Pavón Jiménez, with an experienced French botanist, Joseph Dombey.[95] In 1761 the Spanish Enlightenment naturalist José Celestino Bruno Mutis y Bosio became personal physician to the Viceroy of New Granada. Two years after his arrival in the Viceroyalty, Mutis began the slow process of petitioning Charles III to support the exploration of the natural history of his new home.[96] After two decades Mutis got approval, and he led the second Royal Expedition (1783–1816) until his own death. In Spanish America, these expeditions became part of inter-Viceroyalty economic and political rivalry over the lucrative bark trade.[97] Meticulous exploration by Mutis and his colleagues produced vast amounts of data about the plants of New Granada, including thousands of botanical illustrations by people he had trained, and tens of thousands of plant specimens.[98] Ruiz, Pavón and Dombey were equally productive, although their collections became embroiled in the complexities of imperial politics between Spain, France and Britain. Eventually, botanical materials from both Royal Expeditions were returned to Madrid. Some data from the Viceroyalty of Peru were published and circulated; those from New Granada were consigned to archival obscurity.

Cinchona hirsuta is one of many new species in the quinine genus first described and illustrated in Hipólito Ruiz López and José Antonio Pavón Jiménez's *Flora Peruviana, et Chilensis* (1799) following their fieldwork in South America. Engraved plates were made by V. P. Perez based on original watercolours by Francisco Pulgar.

Ruiz and Pavón published 325 black-and-white engravings from their expedition in three volumes of their *Flora Peruviana, et Chilensis* (Peruvian and Chilean Flora, 1798–1802), of which nine plates were of fever-tree species.[99] The images, made by many engravers in Madrid, were based on the work of numerous illustrators. The highly stylized watercolours of fever-tree species made by Mutis's artists were eventually published as 31 chromolithographs by a lithographer called Grabowski in the Colombian botanist José Jerónimo Triana Silva's *Nouvelles études sur les quinquinas* (New Studies on Quinines, 1870).[100]

By the mid-nineteenth century malaria was ravaging British and Dutch colonial interests in southern and southeastern Asia, so cheap, reliable sources of locally grown bark were essential. Arguments for introducing the fever tree outside its native range were made in terms of the conservation of resources and the prevention of apparently wasteful harvesting practices whereby mature trees were coppiced or felled to collect the bark.[101] William Dawson Hooker's evidence that coppicing was the best method for maintaining the growth of the fever tree was overlooked, as schemes to introduce quinine to British India were promoted.[102] A European race had begun to procure fever-tree seed from the Andes. In 1860 the Amazonian explorer Richard Spruce collected seeds and plants of Ecuadorian fever trees at the behest of the geographer Clements Robert Markham.[103] Trees from this material were eventually established in India and, until the early twentieth century, were the primary source of quinine for British India.[104] Another source of fever trees was the alpaca-wool dealer Charles Ledger, who in 1865 illegally removed fever-tree seeds from Bolivia. Trees raised in Java from these seeds were the basis of quinine production until 1939, because they contained more than 30 times more active ingredients than other cultivated trees.

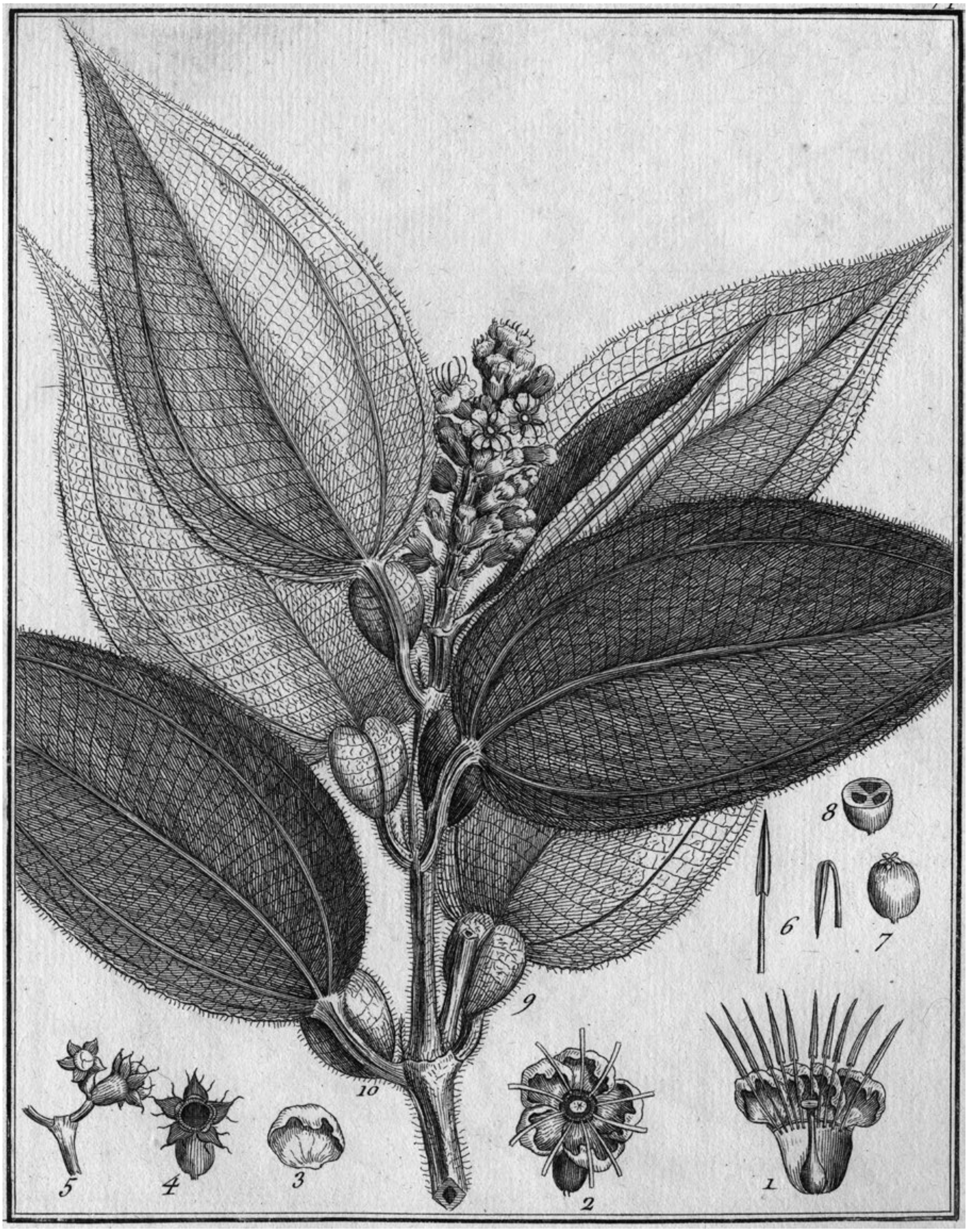
In the nineteenth century the discovery that rubber could be dissolved and moulded, and its elastic properties modified, transformed it from a curiosity with few practical uses to an adaptable, indispensable raw material for industry. The rubber tree, from the Brazilian Amazon, produced ideal industrial rubber, but almost nothing was known about the plant. Into this gap came *Rough Notes of a Journey through the Wilderness from Trinidad to Para, Brazil, by Way of the Great Cataracts of the Orinoco, Atabagao, and Rio Negro* (1872), by the roguish adventurer and would-be planter Henry Wickham. This book included not only a brief account of the tree and how it was tapped for rubber, but also a black-and-white lithograph of Wickham's rough sketch of a leaf, fruit and seed – one of the few drawings of the tree known at the time.[105] With the support of Markham, Joseph Hooker, now director of the Royal Botanic Gardens at Kew, asked Wickham to collect seeds. Wickham arrived at Kew on 14 June 1876 with tens of thousands of seeds from Brazil. These were germinated at the botanic garden, and by August thousands of surviving seedlings had been shipped to fledgling plantations in Sri Lanka – seedlings that contributed to the Southeast Asian rubber economy.

Accuracy, precision and compassion

Service in the church, military and civil service have often attracted people interested in natural history. With time to explore often remote locations, many such people made first-rate botanical collectors and illustrators. The eighteenth-century French apothecary and administrator Jean Baptiste Christophore Fusée Aublet was such a man: 'every moment my duties allowed were devoted to finding plants . . . describing them with all possible care on the spot.'[106] However, unlike many of his contemporaries, Aublet recorded the help he received from indigenous and enslaved peoples. Indeed, his first-hand knowledge of slavery in the French colonies of the Indian Ocean and the Americas made him a vocal, secular opponent of slavery in a period when such views came at great personal sacrifice.[107]

By the time Aublet joined the French East India Company, in 1751, with the tasks of establishing facilities for medicine production and creating a garden of useful plants on Mauritius, he was already an accomplished botanist.[108] After nine years he returned to France, although a vitriolic

The pink-flowered shrub *Tococa guianensis* is distributed through the tropical areas of Central and South America. Jean Baptiste Christophore Fusée Aublet adopted the Galibis common name, *tococo*, as a new generic name for this plant, which has prominent, heart-shaped double bladders at the base of each leaf. Based on information from local people, Aublet emphasized that the bladders were the homes of ants and that there was an association between plant and ants; locals even called the plant 'ant's nest'. The illustration, from Aublet's *Histoire des plantes de la Guiane Françoise* (1775), by an unknown artist trained by the author, includes detailed, magnified dissections of flowers and fruit. Today, this species is formally known as *Miconia tococa*.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rivalry had developed between him and Pierre Poivre, who was working as a botanist for the French government on the island.[109]

Aublet was rewarded for his Mauritian service with the position of apothecary and botanist in French Guiana. King Louis XV was trying to tempt his people to settle the colony – the rump of France's South American ambitions. However, rather than a promised land of easy fortunes, settlers faced an unfamiliar environment, unknown tropical diseases and hostile local people. Aublet arrived in the colonial capital in 1762, and spent two years collecting plants before ill health forced him back to France. On his way home, he stayed in the northwestern peninsula of the Colony of Saint-Domingue (now Haiti). Throughout his collecting activities in Mauritius, French Guiana and Haiti, Aublet recorded the botanical knowledge, such as plant names and uses, of indigenous peoples and enslaved Africans.[110] He returned to France with a vast collection of herbarium specimens, notes and sketches.

Ten years later Aublet published his multi-volume *Histoire des plantes de la Guiane Françoise* (History of the Plants of French Guiana, 1775), stating proudly that it presented 'plants which have not yet been described or engraved, or which have only been imperfectly'.[111] He described more than 1,200 species, of which over four hundred were new to European botanists. Moreover, he incorporated indigenous names into the scientific names of many of the new plants, leading some botanists to try to replace them because they thought the names 'barbaric'.[112]

Plants are illustrated across 393 black-and-white plates, the work of numerous metal engravers, based on the illustrations of draughtsmen trained by Aublet: 'The Draughtsmen seeking to make pleasant rather than correct designs, and not having the habit of drawing plants in the degree of accuracy and precision necessary for Botany, I was obliged to train an Artist to represent all of them.'[113] Close comparison of the original drawings and etched plates has led to the conclusion that 'drawings do not always match the final engraved plate . . . suggesting that the mixtures reported from some plates may be due to errors in supplying drawings to the engravers.'[114] However, Aublet made clear that the cause of any deficiencies in the illustrations was financial: 'if I had been either richer or helped with the expense of the plates for this Work, the designs would not have been more exact, but the engraving would have been more pleasing

to the eye.'[115] Despite the confusion associated with these illustrations, they remain fundamental to the understanding of plant diversity in the tropical and subtropical Americas.

IN THE ANNALS of botanical exploration, illustrators have been essential for the recording and transmission of information about plants – part of that lesson in humility learned when the activities of field botanists are investigated in detail. Moreover, scientific botanical illustrations created from collecting in the field, which are copied and recopied into more popular media (albeit perhaps removed from the contexts in which they were created), give people an appreciation of the sheer diversity of the planet's plants.

As the careers of Humboldt, Darwin and Joseph Hooker demonstrate, Cuvier's dichotomy of 'field naturalists' and 'closet natural historians' is too simplistic, and in fact at different stages in their careers, people take different roles. Popular, romantic caricatures of plant collectors as botanical simulacra of Indiana Jones are not borne out by the evidence. Moreover, triumphant tomes proclaiming the adversities overcome by explorers to discover foreign lands and fill the European museums and gardens grate on today's sensibilities. These lands, and the plants growing on them, were not unknown; it was Europeans who were ignorant of them. Indeed, the fact that Europeans used local, often unnamed guides and their knowledge as they moved through 'unknown' landscapes, adding lustre to their own reputations, is implicit acknowledgement that they were not the 'first'.

85 Cameleon.
169 Matelas rose
58 Dorothea [fin].
115 Grootmeester van Malta.
111 Gouden Standaard.
168 Ville de Haarlem.

five

GARDEN AND GROVE

> Here [Canton, China] he is surprised to see the number of flowers and flowering plants which every where meet his eye: every house, window, and court-yard are filled with them!
>
> JAMES MAIN, *Gardener's Magazine* (1827)[1]

For millennia, cultures around the world have made gardens to produce food and medicine, to pursue entertainment and relaxation, and to advertise power and position.[2] Wild plants have been collected, propagated and manipulated to satisfy horticulturalists' demands for novelty. Gardens are stocked with species, particular forms or mutations, or things extracted from their native homes in exotic manners. Indeed, dramatic tales associated with a plant's properties or collection may justify its inclusion in garden landscapes. In the game of horticultural one-upmanship, the exotic is a lure, and distant locations make plants prettier and more desirable than those obtained close to home. Consequently, gardens and the plants in them may also be read as palimpsests of political, economic and social opportunities, tension and exploitation.

Wild tulips, the ancestors of today's cultivated tulips, which are found in montane regions of western and central Asia, were intrinsic elements of early Islamic gardens.[3] The Ottoman conquest of Constantinople meant that imperial gardens were established, and the elongate, flame-shaped tulip was even adopted as a state symbol – especially under Suleiman the Magnificent in the sixteenth century – and incorporated into decorative designs.[4] The French naturalist Pierre Belon drew Europeans' attention to tulips following his Levantine travels in the late 1540s. A decade later the Swiss naturalist

Six mid-nineteenth-century European tulip cultivars: 35, 'Cameleon'; 169, 'Matelas rose'; 58, 'Dorothea'; 115, 'Grootmeester van Malta'; 111, 'Gouden Standaard'; 168, 'Ville de Haarlem'. Hand-coloured offset lithograph presented to readers of the journal *Flore des serres et des jardin de l'Europe*.

Conrad Gesner saw tulips growing in a German garden. One of the earliest tulip illustrations in Western literature is a woodcut in Pietro Mattioli's *Senensis medici, commentarii in sex libros* (Doctors of Siena, a Commentary in Six Volumes, 1565), by which date the Flemish botanist Charles de l'Écluse (also known as Carolus Clusius), who founded the botanic garden at Leiden, was busy distributing these plants across Europe.[5] In contrast to the Ottomans, Europeans preferred tulips with rounded, torch-shaped blooms.

In the early seventeenth century the Netherlands entered the so-called Dutch Golden Age, when enormous wealth from trade and exploitation, highly skilled labour and cheap energy combined to create a European economic, political and cultural powerhouse.[6] Dutch gardeners, painting with flowers, created elaborate gardens filled with exotic plants, accentuating the wealth and social position of their masters. Moreover, the tulips that were created as florists selected for particular features, such as characteristics of shape and colour, contributed to the expanding market for lavishly illustrated garden books.[7]

In 1841 the Scottish journalist Charles Mackay wove an account of how, between 1634 and 1637, the Netherlands had succumbed to 'tulipomania'.[8] His tale was that of Dutch tulip merchants evolving sophisticated futures markets of promissory notes, where speculators bet vast amounts on bulbs producing the admired and desirable 'broken' blooms. In such blooms, the usually solidly coloured petals are marked with exotic feathered or flame-like patterns that we now know are caused by aphid-transmitted viruses. Mackay argued that tulipomania was a financial bubble that expanded until someone asked the 'new-clothes question'. This happened in 1637, precipitating the collapse of the tulip market and sending economic ripples throughout Dutch society. Despite challenges by economic historians to Mackay's interpretation of events, tulipomania remains a commonplace in the mythology of this flower.[9]

Once the preserve of sultans, monarchs and princes of commerce, images of tulips were by the mid-seventeenth century gracing some of the most exclusive illustrated botanical books published in Europe. Yet the apparent democratization of their cultivation failed to destroy the appeal of tulips as spring flowers.

European gardens have been stocked from across the world.[10] From the gardens of the Aztecs, they were populated with that 'fierce monster

of the flower-shows', the dahlia.[11] From Chinese and Japanese gardens was introduced another flower-show staple, the chrysanthemum. This chapter focuses on the function of botanical illustrations in recording, advertising and selling plants to Western gardeners.

Recording European gardens

Garden owners have long kept accounts of botanical treasures in their care. Private written and illustrated records may be for the purposes of their own management or for circulation among friends, while publications are for peers and perhaps future generations. John Gerard and John Parkinson recorded the contents of their London gardens (in Holborn and Long Acre, respectively) in books illustrated primarily with borrowed woodcuts.[12] The contents of academic gardens, such as those at Leiden, Oxford and Paris, and royal gardens, such as those of the chateau of Gaston, Duke of Orléans at Blois and the Royal Botanic Gardens, Kew, were documented in unillustrated, printed lists. Of course, our knowledge of the plants being grown is now of necessity biased towards those who had the leisure, money and inclination to record the contents of their gardens.[13]

Such lists can be, and are, used to create league tables, to judge and compare, and gardens with more species, and more rarities or unique plants, rank high in such tables. Yet lists of names, without reference to either illustrations or physical specimens, cannot be compared objectively; they rely solely on the authority of the compiler.[14] An alternative to a plant list is the florilegium, a showcase compilation made 'largely or entirely of pictures of flowers'.[15] The owners of large gardens, or those concerned with broadcasting their prestige, contributed to the eighteenth- and nineteenth-century era of the 'great flower books', in which horticultural triumphs were displayed in elaborate collections of printed illustrations.[16]

Florilegia may be private portfolios of unpublished illustrations, or published as journals or coffee table-style books. An unpublished florilegium by the Dutch artist Everardus Kickius, together with herbarium specimens, documented the gardens of Mary Somerset, Duchess of Beaufort, one of the foremost gardeners of late seventeenth-century Europe.[17] Rather than just recording garden contents, some illustrators used published florilegia for other purposes. The British natural-history illustrator William Hooker

(not to be confused with the director of Kew Gardens), inventor of the pigment Hooker's Green and the only commoner to be a student of the illustrator Franz Bauer, was official artist to the Horticultural Society of London (now the Royal Horticultural Society).[18] By the early twentieth century he was recognized as a 'painter of fruits [who] has never been equalled in this country [Britain]'.[19] Writing in the third person, Hooker stated his motivation for preparing the 117-plate, part-work florilegium *The Paradisus Londinensis* (1805–8) as

> having been at length enabled by their (Collectors of Plants) liberality to bring forward . . . some of the efforts of his pencil, it would be dastardly in him not to own that his hopes of success overbalance his fears; it now only remains with the Public at large to appreciate his labours, and become his best patrons. Anxious however for fame, rather than inordinate profit, he will be content with very small interest for the sums advanced.[20]

Hooker's intention was to include in the *Paradisus* plants that were 'new, uncommonly beautiful, or incompletely figured by others'.[21] The necessary sums were not advanced for long, however, forcing him to abandon publication.

The *Hortus Eystettensis* (Garden of Eichstätt, 1613) was published a year after the death of its wealthy patron, Johann Konrad von Gemmingen, prince-bishop of Eichstätt. For sixteen years the Nuremberg apothecary Basil Besler had coordinated work on this massive illustrated catalogue of the plants growing in the garden of the prince-bishop's palace.[22] Besler employed a team of artists, engravers, printers and colourists to produce three hundred copies of the first edition, which was printed on the largest-sized paper available in sixteenth-century Germany. Some 367 printed plates depict more than 1,000 plants, which are arranged according to the seasons of the year.[23] One of the illustrators was the German artist Sebastian Schedel. Engravers included Peter Isselburg and Wolfgang Kilian, while Georg Mack the Younger was employed to hand-colour the printed plates. Uncoloured copies of the *Hortus Eystettensis* cost 35 florins, while deluxe coloured copies cost five hundred florins. Besler's primary interest in the scheme appears to have been financial. The project was underwritten by

Engravings of the flowers and tubers of 'Papas Peruanorum' (potato), and flowering plants of 'Serpillum citratum' (lemon thyme) and 'Thymus vulgatin' (common thyme), made by the team of artists and engravers who illustrated Basil Besler's *Hortus Eystettensis* (1613).

II. Serpillum citratum.

I. Papas Peruanorum.

III. Thymus vulgatior.

the vast financial resources available to the prince-bishop, although he never saw the work completed. Despite its high costs, the *Hortus* sold well, enabling Besler to purchase property in his home city.

When published, the *Hortus Eystettensis* was distinctive in two respects. First, the plates, with their bold arrangements of images, were dramatically different from any previous botanical illustrations; one reviewer summarized them as 'being very large, and all curiously cut in brasse, and printed vpon the largest paper'.[24] Second, the book's sheer physical size – requiring it to be hauled from shelf to desk – made it an object of novelty rather than daily, practical use. By modern standards, the accuracy of the plates was frequently sacrificed for decorative effect, especially when compared to many of the period's less ostentatious botanical images. Consequently, the *Hortus* has limited scientific value, and modern identifications cannot be made with great accuracy. The *Hortus* is today more familiar for its separated plates, which command high prices as framed prints, rather than as the first of the grand florilegia with a prominent place in the history of botanical illustration.

Described as the 'most important book to be published in England during the eighteenth century on the plants growing in a private garden', Johann Jakob Dillenius's *Hortus Elthamensis* (Garden of Eltham, 1732) illustrates rare, usually exotic plants growing in the royal apothecary James Sherard's garden at Eltham, Kent (now in Greater London).[25] Between the boards of the two-volume, royal-folio *Hortus*, Dillenius described 418 plants, which he illustrated from life and engraved across 325 copperplates. Approximately 155 uncoloured copies of the *Hortus* were published, while only three copies were hand-coloured – all by Dillenius himself.[26] The plants illustrated in the *Hortus*, which are mostly from Africa, the Americas, Asia and Europe, include many succulents that need specialized conditions to grow and were consequently difficult and expensive to maintain in early eighteenth-century glasshouses. As Dillenius expected, the *Hortus* was a 'book of but few people's buying', a fact that was not helped by the letterpress being in Latin, by the absence of subscribers and by Dillenius's rivalry with the English botanist John Martyn, who was busy publishing *Historia plantarum rariorum* (1728–37).[27]

However, unlike those of many florilegia of the period, the illustrations in the *Hortus* are scientifically important because of their incorporation

The China aster as drawn, engraved and hand-coloured by Johann Jakob Dillenius for his *Hortus Elthamensis* (1732). The aster is a short-lived species, native to China, Korea and Japan, which has been cultivated in its native range for at least 2,000 years and in Europe since 1728. The plant illustrated by Dillenius was grown in James Sherard's garden at Eltham, from fruit that had been sent to him from Leiden by the Dutch botanist Adriaan van Royen. Until the end of the nineteenth century, Dillenius's illustration was one of only two 'really good' illustrations of the China aster.[28]

into the works of Linnaeus, which form the basis of modern plant-naming systems.[29] Dillenius, who has been described as a 'patently thin-skinned "workaholic"',[30] resented the time he spent on this project and grew to dislike Sherard: 'I should have made a book in quarto or small folio; but he [Sherard] did not like it, and hath made me draw over fifty more plates, to make it look bigger and more pompous.'[31] In turn, Sherard complained

about Dillenius's work on the *Hortus*: 'You will see that he has not studied either to adorn his book or my garden; his chief care having been to improve and advance the knowledge of botany.'[32] Dillenius's and Sherard's comments reveal tensions familiar in the publication of botanical works, including the balance between illustrations and text, price versus circulation, and the relative interests of the author, illustrator, sponsor and publisher.

The Dutch botanist Nikolaus Joseph von Jacquin collected talented botanical artists in Vienna to immortalize the gardens of the Schönbrunn Palace, publishing sumptuous, limited-edition volumes beyond the pockets of all but the wealthiest patrons.[33] While at Malmaison, the Belgian

Hand-coloured engraving of the cochineal cactus published in *Plantes grasses de P. J. Redouté* (Succulents of P. J. Redouté, *c.* 1802), based on an original illustration by the French illustrator Pierre-Joseph Redouté. In Europe, the cochineal cactus, a species native to Mexico, was grown as a horticultural curiosity. It is the host plant of the scale insect *Dactylopius coccus*, source of the red dye cochineal.

artist Pierre-Joseph Redouté painted flowers for Joséphine Bonaparte.[34] Despite his extensive contribution to major scientific works of European botany in the late eighteenth and early nineteenth centuries, Redouté is best known as a recorder of royal and imperial gardens, a role that was interrupted temporarily by the decapitation of Marie Antoinette in 1793.[35]

With the sycophancy of the patronized, the French botanist Étienne Pierre Ventenat praised the novelty of Joséphine's garden at Malmaison: 'you have before your eyes the rarest plants on French soil . . . the sweetest souvenirs of the conquests of your illustrious husband.'[36] Across 120 stipple-engraved, hand-coloured folio-sized plates, based on original illustrations by Redouté, some of these rarities were presented in the limited-edition (two hundred copies) two-volume part-work *Jardin de la Malmaison* (The Garden of Malmaison, 1803–5). In one of Redouté's most celebrated works, *Les Roses* (The Roses, 1817–20), published after Joséphine's death, approximately half of the roses illustrated came from Malmaison.

The two-volume *Highgrove Florilegium* (2008–9), produced for Charles III (then Prince of Wales), is a modern example of a large-format, limited-edition, high-cost volume of botanical illustration printed to very high standards and highlighting the contents of a single garden.[37] When 76 colour offset plates of the Australian botanical illustrator Celia Rosser's watercolours of the iconic Australian genus *Banksia* were published, only a limited-edition elephant folio (560 by 775 millimetres/22 by 30½ in) was considered suitable.[38] However, unlike a florilegium, Rosser and Alexander George's three-volume *The Banksias* (1981–2000) was at the time a complete botanical account of all members of the genus, although during the twenty-first century the genus *Banksia* has more than doubled in size.[39]

Lavishly illustrated, subscription-funded part-work florilegia appeared and disappeared regularly in the eighteenth and nineteenth centuries as initially enthusiastic authors and subscribers overstretched both their ambitions and their resources. The young English botanist John Lindley was forced to abandon publication of his *Collectanea botanica: or, Figures and Botanic Illustrations of Rare and Curious Exotic Plants* (1821–6):

> It was his [Lindley's] determination that neither care nor cost should be spared in making it worthy of public support: and, as pecuniary remuneration was never expected, the

> price was only calculated to defray the actual expenses incurred in the course of its publication. A variety of circumstances, which it is not necessary to mention here, have, however, induced him to swerve from his original designs and resolve upon abandoning the undertaking altogether after the publication of four more numbers.[40]

In eighteenth-century Europe, illustration-led part-works also began to be published for an audience, with more modest pockets, that valued coloured images of rare or unusual plants. William Curtis's *Botanical Magazine* (later *Curtis's Botanical Magazine*), the world's longest-running continuously published botanical magazine, was founded in 1787.[41] The *Botanical Register* (later *Edwards' Botanical Register*) was started by the botanical illustrator Sydenham Teast Edwards in 1815 and was published until 1847, while the *Floral Magazine* was published between 1861 and 1881. These aspirational publications, with their high reproduction values, were aimed at creating enthusiasm for and diffusing knowledge about plants. In contrast, weekly horticultural periodicals, such as the *Gardeners' Chronicle* (founded 1841; currently *Horticulture Week*), were cheaper, aimed at working, practical gardeners, and illustrated primarily with black-and-white wood engravings.

Of course, the plants illustrated in florilegia and horticultural journals were perfect examples. Grown in European gardens and glasshouses and recorded at the peak of their flowering or fruiting, they were rarely depicted with the imperfections wrought by a more natural environment.

Aristocratic associations

By the mid-nineteenth century, like other European gardens, the Royal Botanic Gardens at Kew were at the centre of a web of organizations linking national commercial and scientific expectations with the botanical resources of Britain's colonies. One of Kew's concerns was the discovery of species, which comes with the opportunity to assign scientific names. These are names that could be used to honour, denigrate or flatter, despite Linnaeus's warning that they 'should not be misused to gain the favour, or preserve the memory, of saints, or of men famous in some other art'.[42]

The dramatic glasshouse bird-of-paradise plant, a native of South Africa, was illustrated in vol. IV of William Curtis's illustrated *Botanical Magazine* in 1791. For this dramatic plant, Curtis broke his own rules about the size of images by publishing this hand-coloured, gatefold engraving.

In 1788 Joseph Banks formally named the bird-of-paradise plant *Strelitzia reginae* in honour of Charlotte of Mecklenburg-Strelitz, queen consort of George III and a patron of Kew Gardens. Nearly fifty years later the Danish botanist Nathaniel Wolff Wallich, superintendent of the Royal Botanic Garden in Calcutta, named the pride of Burma *Amherstia nobilis* 'after the Right Honourable Countess [Sarah] Amherst and her daughter Lady Sarah Amherst, the zealous friends and constant promoters of all the branches of Natural History, especially Botany'.[43]

By the time it was named, the bird-of-paradise plant, with its upright, banana-like leaves and inflorescence 'containing about six or eight flowers, which becoming vertical as they spring forth, form a kind of crest, which the glowing orange of the Corolla, and fine azure of the Nectary, renders

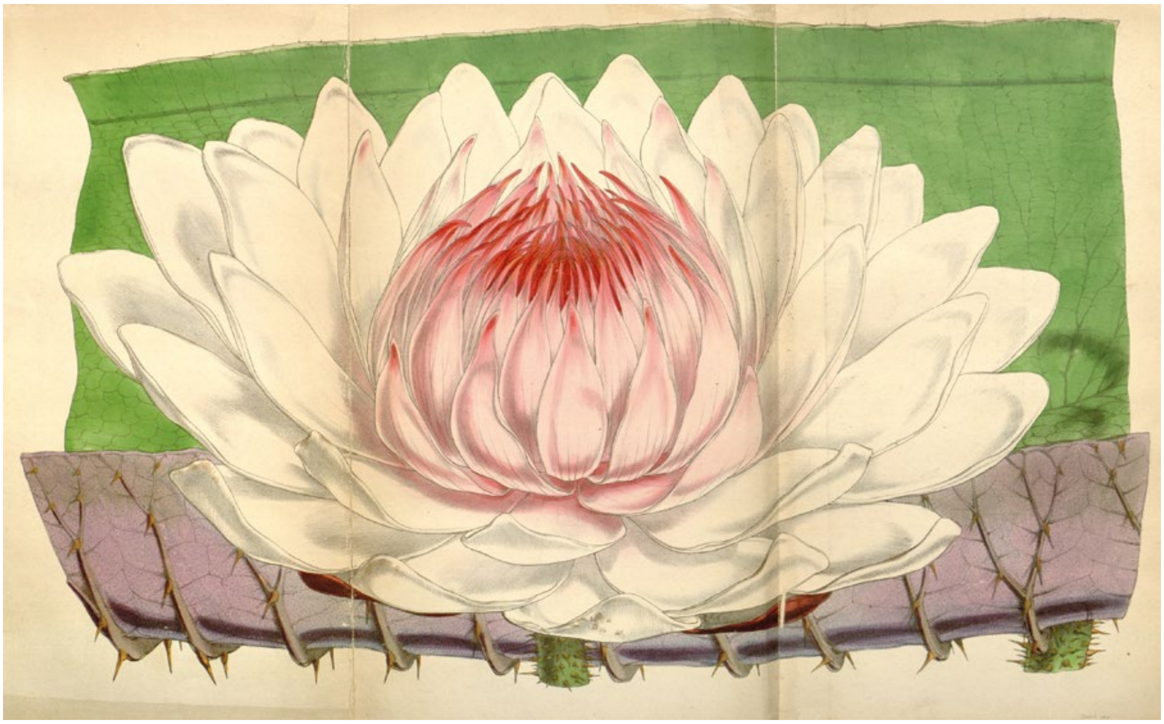
truly superb', was already growing at Kew.[44] This rare, dramatic plant with colonial connections and royal associations became symbolic of Banks's ambitions for the garden. Moreover, the difficulty of cultivating it created a challenge for ambitious garden owners.

In 1791 Curtis published the first gatefold, hand-coloured engraving in his *Botanical Magazine* – and it was of *Strelitzia*. He justified the decision thus: 'that we may give our readers an opportunity of seeing a coloured representation of one of the most scarce and magnificent plants introduced into this country, we have in this number deviated from our usual plan, with respect to the plates.'[45] However, he was cautious about his audience's reaction: 'we are not without our apprehensions least others may not feel perfectly well satisfied; should it prove so, we wish such to rest assured that this is a deviation in which we shall very rarely indulge, and never but when something uncommonly beautiful or interesting presents itself.' The experiment was not repeated for another thirteen years.[46]

The association of *Strelitzia reginae* with high-profile figures came full circle when, in the 1990s, a rare yellow-flowered mutation discovered in Africa was given the name 'Kirstenbosch Gold', then re-christened 'Mandela Gold' in honour of the South African politician Nelson Mandela.[47] However, outside Africa, the principle of name priority ensures that the former name remains in use.

In 1826 Wallich received dried scraps of the pride of Burma from a Burmese monastery garden. The tree, described by the collector, a Mr Crawford, as 'too beautiful an object to be passed unobserved even by the uninitiated in botany', led Wallich to search for additional specimens.[48] A year later he found two trees, about 12 metres (40 ft) tall, growing in another Burmese monastery garden, 'profusely ornamented with pendulous racemes of large vermilion-coloured blossoms, forming superb objects, unequalled in the Flora of the East Indies

Chromolithograph of the pride of Burma by Maxim Gauci based on an illustration by Vishnupersaud in Nathaniel Wolff Wallich's *Plantae Asiaticae rariores* (Rare Asiatic Plants, 1830). Wallich reported that the flowers were used as votive offerings in Buddhist temples, but he found that people knew nothing about the tree. He concluded that this was an example of the 'profound ignorance and indifference of that nation [Myanmar] concerning all matters connected with the natural productions of their country'.[49]



One of four hand-coloured lithographs made by Walter Hood Fitch and published in *Curtis's Botanical Magazine* to celebrate the Amazonian water lily. Since its discovery by Europeans in the early nineteenth century, people have had hyperbolic reactions to this plant, whether in the wild or in cultivation. Aimé Bonpland 'well nigh precipitated himself off the raft into the river in his desire to secure specimens', while Thomas Bridges would have 'plunged into the lake to procure specimens of the magnificent flowers and leaves', but was deterred by alligators.[50] When the gardener Joseph Paxton managed to get a plant to flower in Britain, he showed it off by having his daughter dress in a fairy costume and stand on one of the water lily's leaves.[51]

and, I presume, not surpassed in magnificence and elegance in any part of the world'. Wallich was accompanied by his 'draughtsman', the Indian artist Vishnupersaud, who was employed so that he could 'compare and correct the figure' made from the earlier specimens.[52] The publication of Vishnupersaud's illustration of the pride of Burma stimulated acquisitive, competitive instincts among British gardeners.[53]

Wallich established the tree in Calcutta, but failed to return living material to Britain. In 1839 William George Spencer Cavendish, 6th Duke of Devonshire (whose collaboration with the gardener Joseph Paxton created one of the foremost collections of rare, exotic plants in Europe at Chatsworth House, Derbyshire), claimed the prize for the first cultivated example of the pride of Burma in Britain. However, the English horticulturalist Louisa Lawrence, on her husband's estate at Ealing Park, west of London, beat the duke to the flowering prize. Lawrence obtained her plant from the governor-general of India, Henry Hardinge, in 1847; it flowered two years later. Lawrence underlined her triumph by sending one raceme of flowers to Queen Victoria, and another to William Jackson Hooker, director of Kew, where 'an atlas-folio drawing' was made: 'a size which can

alone do justice to such a subject'.[54] In 1842, a year after taking up the position at Kew, Hooker had dedicated a volume of *Curtis's Botanical Magazine* to Lawrence, 'the beauty of whose gardens and pleasure grounds and whose most successfully cultivated vegetable treasures are only equalled by the liberality with which they are shown to all who are interested in botany and horticulture'.[55] Today, the pride of Burma remains a horticultural spectacle in the humid tropics, although it has not been reported growing wild since 1865.[56]

The duke and Paxton's consolation prize, in 1849, was to be the first to persuade into flower the giant Amazon water lily, *Victoria amazonica* (formerly *V. regia*), another spectacular plant christened scientifically to flatter a British monarch.[57] Two years earlier Hooker had tempted the audience of *Curtis's Botanical Magazine* with four hand-coloured plates, accompanied by a detailed account of the plant's discovery.[58] The form of the water lily's leaves inspired the structure of such glasshouses as the Crystal Palace, built to house the Great Exhibition of 1851, and the Palm House at Kew.

Looking east

For millennia, valuable spices, perfumes and textiles entered Europe via the great eastern trade routes, along with extravagant and exotic reports of the lives of those who inhabited the lands beyond the Mediterranean Sea. Few living plants entered Europe along these routes, so the origins of plant products were sometimes shrouded in mystery. For example, until the nineteenth century European tea drinkers did not realize that black and green tea came from the same plant.

However, living citruses, with their East Asian origins, did spread slowly around the world along trade routes and with colonization.[59] According to a Japanese myth of the Kofun period (*c.* 300–538 CE), one Tajimamori was sent by the legendary Emperor Suinin in search of the elixir of immortality, the 'ever-fragrant fruit' – presumed to be the native Chinese mandarin orange.[60] By the seventeenth century tender citrus was fashionable in Europe, where the 'benefit it affordeth us, consisteth in the beauty of the evergreen leaves, and sweet-smelling flowers, the fruit in our cold Countrey never coming to maturity'.[61] For all but a few months in the summer, protection was essential to keep citruses alive. Specific

buildings known as orangeries developed to house these tender plants, and some examples – built with the limitless wealth and labour available to monarchs, for example – were magnificent, such as that at Versailles. Unsurprisingly, citruses also became popular with botanical illustrators, among them those responsible for the eighty metal engravings in the Italian botanist Giovanni Battista Ferrari's *Hesperides sive de malorum aureorum cultura et usu* (The Hesperides; or, Concerning the Cultivation and Use of the Golden Apples, 1646).

For European gardeners with sufficient wealth and leisure, eastern Asia offered the prospect of immense horticultural novelty.[62] Descriptions and illustrations of magnificent gardens cultivated by the mighty added to Western impressions of an exotic East. Tales of the dangers faced and ruses adopted as Western travellers attempted to collect horticultural plants, while restricted to coastal trading posts in China and Japan, only fed European cravings.

Among the most magnificent East Asian gardens were those of the imperial palace complex of Yuanming Yuan ('Gardens of Perfect Brightness') near Beijing, the primary residence and gilded cage of the Qianlong Emperor and his successors.[63] In 1743, some two decades after the construction of Yuanming Yuan began, the French Jesuit missionary Jean Denis Attiret painted an enthusiastic word portrait of the palace, its gardens and the well-watered, forested landscape in which all was set.[64] Moreover, the imagination of powerful Europeans was captivated by chinoiserie and East Asian artistic traditions. In Britain, the most famous surviving artificial garden chinoiserie is the Great Pagoda at Kew, erected in 1761 and based on designs by the Swedish-Scottish architect William Chambers.[65] However, it is the wild and cultivated plants of China and Japan – botanical chinoiserie – that have retained their place in European gardens, including buddleias, camellias, cotoneasters, forsythia, hardy gloxinias, jasmines, kerria, lilies, magnolias, maples, paeonies, rhododendrons, spiraeas, sweet olives, viburnums, wisterias and witch hazels.[66]

Some of these plants, such as rhododendron, were familiar to late eighteenth-century gardeners. However, those introductions from North America and continental Europe were swamped, during the nineteenth century, by species from the Himalayas and China.[67] In northeastern Nepal, during two November days in 1849, a team led by Joseph Hooker gathered

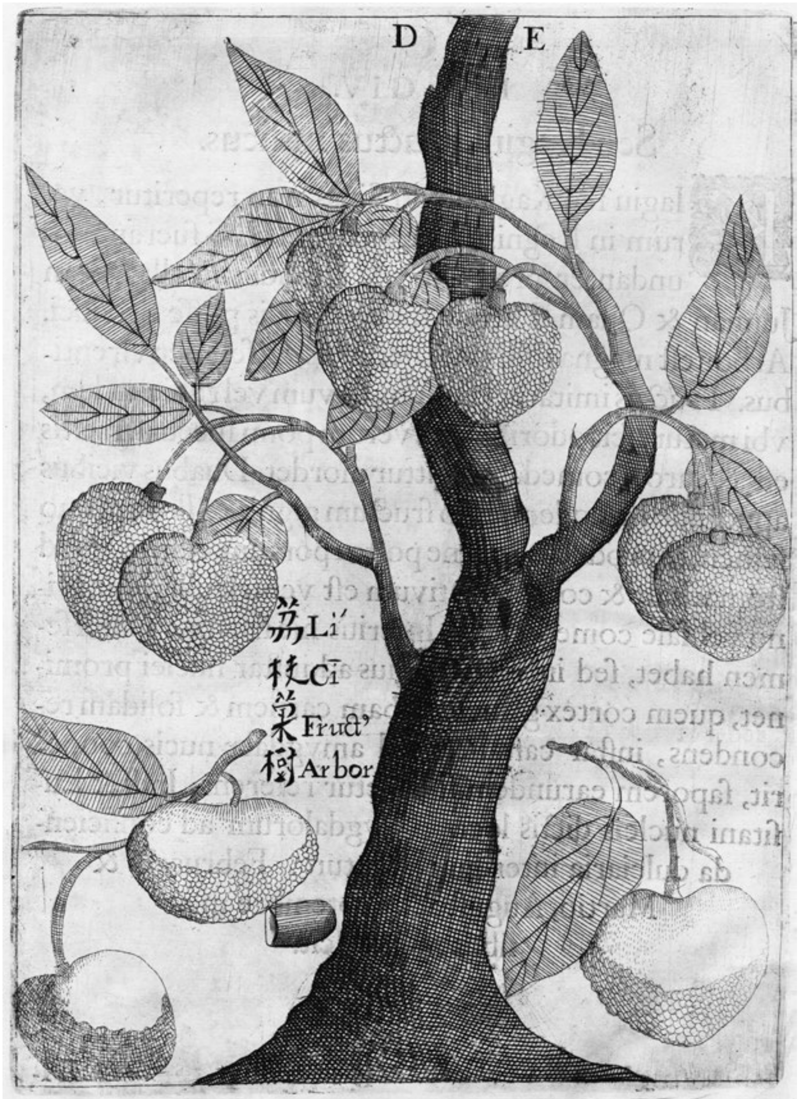
Lithograph of the Himalayan shrub *Rhododendron thomsonii* by Walter Hood Fitch, based on drawings made in the field by Joseph Dalton Hooker, from Hooker's *The Rhododendrons of Sikkim-Himalaya* (1849–51). Hooker includes magnified detail of a stamen, pistil and section through an ovary. The species was named in honour of Thomas Thomson, Hooker's 'earliest friend and companion during my College life, and now my valued travelling companion in Eastern Himalaya'.[68]

seeds from 'twenty-four kinds' of rhododendron, which were subsequently introduced into British gardens.[69] Between 1849 and 1851 Hooker's father, William Jackson Hooker, edited *The Rhododendrons of Sikkim-Himalaya*, which was illustrated with thirty imperial folio-sized, hand-coloured lithographs by Walter Hood Fitch. Hooker senior took care to ensure that his audience knew that the 'drawings and descriptions [were] made on the spot' in the field by his son Joseph.[70] A reviewer of the Hookers' work could hardly contain their enthusiasm: 'That he should have ascended the Himalaya, discovered a number of plants, and that they should be published in England in an almost UNEQUALLED STYLE OF MAGNIFICENT ILLUSTRATION, in less than eighteen months, is one of the marvels of our time.'[71]

Many collectors, though, working within plants' native ranges, were more concerned with getting living material back to Europe than with the niceties of illustrating them in the field. Western botanical illustrations of

these horticultural novelties were hence usually based on cultivated plants rather than those growing in their native homes.

One of the first European naturalists to travel east was the Jesuit missionary Michał Piotr Boym, the son of wealthy Polish merchants, who in 1643 went to southwestern China via Portuguese Goa.[72] He returned in 1652 to Europe, where he became involved in the political complexities of relations among the Catholic Church, European monarchs and the Chinese emperor. In 1656, the year he set out on his final journey to China, his *Flora Sinensis* (Chinese Flora) was published in Vienna.[73] It contains



Crude, mid-seventeenth-century diagrammatic etching of the southeastern Chinese lychee tree, 'Li Ci Fruct Arbor', by an unknown artist, from Michał Piotr Boym's *Flora Sinensis* (1656). When the French naturalist Pierre Sonnerat gave the tree its generic name, *Litchi*, he adopted the Chinese common name. The form of the fruit, and the isolated seed, are realistic, but the leaves are shown as simple when in fact they are compound.

23 indifferently etched plates, with Latin and Chinese names, and, despite the 'pretentious title', is primarily a description of the fruit trees likely to be found growing in early seventeenth-century Indian or perhaps Chinese gardens, among them the Brazilian cashew, guava and pineapple, and Indian mango.[74] There is no evidence that Boym introduced Chinese plants to Europe, but some eighteenth-century Jesuit missionaries did return botanical wealth from Chinese gardens. For example, Pierre Nicolas Le Chéron d'Incarville introduced familiar trees, such as the tree of heaven and the pride of India.[75]

After the First Opium War (1839–42), sparked when the Chinese emperor objected to British merchants importing opium, China was forced to sign the Treaty of Nanking, which ceded Hong Kong Island to Britain and established four new treaty ports, in addition to the traditional port of Canton.[76] The Horticultural Society of London saw an opportunity 'to collect seeds and plants of an ornamental or useful kind, not already in cultivation in Great Britain'; the Scottish botanist Robert Fortune was employed to explore China.[77] Among the plants the members of the society wanted for their gardens were 'peaches of Pekin, cultivated in the Emperor's garden'; 'plants that yield tea of different qualities'; 'fingered Citron, called Haong Yune'; 'true Mandarin Orange called Song-pee-leen'; and 'tree and herbaceous peonies'.[78] Using the technological advances offered by the Wardian case for the long-distance transportation of living plants, even with the niggardly funding from the society, Fortune was able to introduce such now familiar plants as winter-flowering honeysuckle, winter jasmine and green-stemmed forsythia.[79] Until 1861, except for short periods in Britain, Fortune was more or less continuously employed in the collection of Chinese plants, as well as the illicit export of living tea plants and the knowledge of tea processing.[80]

The exploration of China by the French missionary-naturalist Armand David led to the discovery of dozens of new species of rhododendron and primula, many of which eventually found their way into European gardens. Among the species with which David is best associated are two south-western Chinese species that he found in 1869. The scientific names of the butterfly bush (*Buddleia davidii*) and the handkerchief tree (*Davidia involucrata*) both commemorate him. The European introduction of these species involved rivalry between two prominent late nineteenth-century

families of nurserymen: Vilmorin in France and Veitch in England.[81] The early Chinese plant-collecting expeditions of Ernest Henry 'Chinese' Wilson, funded by James Veitch & Sons, had the goal of securing seed of these horticultural prizes.[82]

In Japan, as in China, only the fringes of its culture were accessible to foreigners. During much of the Edo period (1603–1867), the gateway was controlled by the Dutch, for whom commerce was perhaps more relevant than curiosity. Dutch traders were largely confined to a fan-shaped trading post of approximately 0.8 hectares (2 acres) on the artificial island of Dejima in the Bay of Nagasaki.[83] Towards the end of the Edo period, the Japanese artist Kawahara Keiga, the 'Painter of Deshima', with his privileged access to the trading post, produced natural-history illustrations for the French artist Charles Hubert de Villeneuve, who lived there between 1825 and 1836.[84] Moreover, with the German botanist and traveller Philipp Franz Balthasar von Siebold, Keiga saw parts of Japan that were forbidden to most Japanese.

Siebold, a difficult man, was an avid natural-history collector whose vast collections of Japanese herbarium specimens and living plants were shipped to the Netherlands, to delight European botanists and gardeners.[85] Some of Keiga's illustrations were redrawn and published as coloured lithographs in Siebold and Joseph Gerhard Zuccarini's three-volume *Flora Japonica* (1835–70). Among the living prizes Siebold returned to European gardens were hostas, hydrangeas and magnolias, although he also introduced the Japanese knotweed, which has since become a problematic weed in Europe and North America.[86] Through an act of botanical theft – the smuggling of tea plants out of Japan – he also has the accolade of founding tea cultivation in Java.[87]

As hostility to foreigners declined in nineteenth-century Imperial Japan, European

Hand-coloured lithograph by Walter Hood Fitch of the jet-bead shrub, published in *Curtis's Botanical Magazine* in 1869, based on the lithographer's own original illustrations. His model plant grew in the Temperate House at Kew, where it had been raised from seed collected by Richard Oldham, probably from around Nagasaki, Japan.

state and commercial interests turned their collective attention to the country's horticultural riches. With nationalistic pride, the editor of the *Gardeners' Chronicle*, John Lindley, was of the view that '[we] see the value of private enterprise in English hands, and how much more efficient it proves than missions entrusted to mere Government agents.'[88] Of course Lindley – who was also secretary of the Horticultural Society, a private organization with its own interests in securing novel garden plants – was *parti pris*. One of the plants Siebold highlighted from the gardens on Dejima was the jet-bead tree, a small, white-flowered member of the rose family that may have been introduced to Japan from its native China.[89] It would prove popular among European gardeners because of its distinctive black fruit. It was first introduced into Western cultivation by the Russian botanist Carl Johann Maximovich via the Imperial Botanical Garden in St Petersburg. In 1869 a plant grown at Kew from Japanese seed collected

Hand-coloured metal engraving of *Schlumbergera russelliana* by Joseph Swan, based on an illustration by Walter Hood Fitch, showing the plant's habit, together with floral details. In early 1837 George Gardner was collecting plants in forests of the Serra dos Órgãos, near present-day Teresópolis, Brazil. He found an epiphytic cactus with cerise flowers, like one he knew from British glasshouses, growing 1,400–2,100 metres (4,600–6,900 ft) above sea level. He could hardly contain his excitement at its horticultural potential, as he returned living specimens to Britain: 'I do trust, if ever I am spared to return to England[,] that I shall see it there as universally cultivated, as the species to which it is so nearly allied.'[90]

by Richard Oldham – the last of the garden's official plant collectors – flowered, to the excitement of the director, Joseph Hooker.[91]

Hooker's father, who had sent Oldham east, was a persistent critic of his 24-year-old gardener, as Oldham reported: 'the tone of Sir William's letter is so harsh & unfavourable towards me, & that he makes no allowance for the trouble & disappointment which I have all along had to encounter.'[92] Hooker's tone is reminiscent of the one he adopted towards the 27-year-old George Gardner, whom he sent to South America in the 1830s to collect plants. Gardner, however, would not be bullied, pointedly telling Hooker that he knew of no one who could have collected, dried, labelled and packed more than 15,000 herbarium specimens (not to mention living specimens) in eleven months in the tropics.[93] The implication was that since Hooker had no experience, he was in no position to criticize. Gardner went on to state that he welcomed 'any hint' on how to do things better, but he underlined his irritation by later inserting the adjective 'useful' before 'hint'.

This was a turning point in Gardner's relationship with Hooker, after which the professor could no longer tell his collector what to do and blindly expect him to do it. Moreover, Gardner's implied threat to give up collecting was potentially devastating for Hooker. With powerful subscribers to satisfy, Hooker had considerable financial and reputational capital invested in Gardner's South American expedition. Gardner proved to be an assiduous collector and botanist, and he went on to discover and introduce two species with global horticultural impact: the cactus *Schlumbergera russelliana*, one of the parents of the Christmas cactus; and the orchid *Cattleya walkeriana*, a species widely used in breeding commercial cattleya orchids.[94]

Autumn and spring

Since the Song dynasty (960–1279 CE), Chinese art has incorporated the 'Four Gentlemen' – four plants associated with different seasons and human virtues: chrysanthemum (autumn; perseverance); plum blossom (winter; uprightness); orchid (spring; purity); and bamboo (summer; humility).[95] Two of these (chrysanthemum and orchid) were not only of interest in the East, but became horticultural obsessions in the West.

Today, thousands of different forms of chrysanthemum have been selected from crosses among genetic lineages introduced from China and

Chromolithograph of a selection of novel, small-flowered horticultural chrysanthemums from the horticultural journal *Flore des serres et des jardins de l'Europe* (1861). Cultivated chrysanthemums collected in China and Japan were enthusiastically received by European gardeners during the nineteenth century, as they selected and modified them to their taste. Hundreds of images of new sorts were published by horticultural journals and trade magazines.

Japan. Even before the chrysanthemum left China for Japanese shores in the eighth century CE, it was probably already a complex species hybrid, and that genetic complexity has only increased over the last century in the West.[96]

The chrysanthemum, which had been grown for thousands of years in China, became known in the West only in the late seventeenth century, with a few desultory attempts to grow it in the early eighteenth century.[97] Serious European interest had to wait until 1789, when a Marseilles businessman, Pierre-Louis Blancard, imported a large-flowered purple variety

from China. A year later it reached British shores, and it was eventually illustrated with a cautious comment that the chrysanthemum 'promises to become an acquisition highly valuable'.[99] In subsequent years additional plants from China added new colours and forms to the chrysanthemum flower head, and by 1826 the Horticultural Society of London could boast 48 varieties in its gardens.[100] All were raised from cuttings, since seed would not ripen in the cold European winters. By the end of the 1820s chrysanthemums had been raised from seedlings, revealing tremendous new variation to delight breeders' eyes. In 1840 the English chrysanthemum enthusiast John Salter had between three and four hundred varieties of chrysanthemum in his nursery at Versailles.

Salter credited the Chinese with generating 'the first sports or rude varieties', which were perfected in Europe: 'the Chrysanthemum of China was . . . almost useless as compared with the Chrysanthemum which is now the most beautiful ornament of our winter gardens.'[101] He was aware of only the tip of a Chinese diversity iceberg; in 1630 more than five hundred cultivars had been recorded in China.[102]

In China in the 1840s, Fortune collected material of small-flowered chrysanthemums, but these were too demure for British taste.[103] French plant breeders were delighted and eventually bred pompon-type chrysanthemums from them. In the 1860s the plants Fortune collected in Japan were of a different order:

> I procured some extraordinary varieties, most peculiar in form and in colouring, and quite distinct from any of the kinds at present known in Europe. One had petals like long thick hairs, of a red colour, but tipped with yellow, looking like the fringe of a shawl or curtain; another had broad white petals striped with red like a carnation or camellia; while others were remarkable for their great size and brilliant colouring.

Chromolithograph of Skinner's cattleya by Maxim Gauci, based on a painting by Augusta Innes Withers, from the original description of the species in James Bateman's *The Orchidaceae of Mexico and Guatemala* in 1839. The name honours George Ure Skinner, the indefatigable businessman and plant collector who brought the orchids of Guatemala to the orchidomanics of early nineteenth-century Britain. Within its native range, the orchid was used to decorate altars. Bateman hoped the plant would not discredit Skinner's name, describing the flower as being of 'the most brilliant and intense rose . . . [with] a delicacy about it which is not surpassed'.[98]

> If I can succeed in introducing these varieties into Europe, they may create as great a change amongst chrysanthemums as my old protegee the modest 'Chusan daisy' did when she became the parent of the present race of pompones.[104]

These plants would transform chrysanthemums in the West, and with them the appearance of Western gardens.

Orchids – the word is derived from the Greek for 'testicles' – are associated in human cultures with exoticism, deception and sex.[105] In the United Kingdom, many have become rare through the indifferent destruction of their habitat. It is perhaps unsurprising, therefore, that the rarest native British orchid, the slipper orchid, is the most flamboyant, having suffered under the knives and trowels of plant collectors.[106] The English businessman James Bateman, reflecting on his enthusiasm for orchid cultivation, wrote:

> *Orchido-Mania* . . . now pervades all (and especially the upper) classes, to such a marvellous extent . . . we send men expressly to all the points of the compass, to swell the number of the species in cultivation; and in this zeal for their introduction, the amateur, the nurseryman, and the public establishment, all vie with each other. The nobility, the clergy, those engaged in the learned professions or in the pursuits of commerce, seem alike unable to resist the influence of the prevailing passion.[107]

Despite Bateman's rhetoric of the levelling effect of orchids, his book *The Orchidaceae of Mexico and Guatemala* (1837–43) revels in the art, artifice and divisiveness of nineteenth-century orchidomania. This book, 'probably the finest, and certainly the largest, botanical book ever produced with lithographic plates', measures 54.5 by 74.5 centimetres (21½ by 29⅓ in.).[108] Subscribers to the 125 copies included Queen Dowager Adelaide of Saxe-Meiningen (to whom the volume was dedicated), Leopold I of Belgium, Leopold II, Grand Duke of Tuscany, and such national and overseas nobility as Francis Russell, 7th Duke of Bedford, William Cavendish and Jules Paul Benjamin Delessert. The book's audience was clearly not all who might have an interest in orchid horticulture, given that

'an epiphyte [orchid]-house is already considered an almost indispensable adjunct to a place of any consideration.'[109]

Together with horticultural advice, forty orchids were described and illustrated in plates made by the Maltese lithographer Maxim Gauci, based on drawings by the British illustrators Sarah Anne Drake, Augusta Innes Withers and Jane Edwards; only one of the drawings was by a man: Samuel Holden.[110] Serious botanical illustrations were supplemented with humorous wood-engraved vignettes based on illustrations by the English caricaturist George Cruikshank. Scientifically, about one-quarter of the species illustrated were new to science, while most of the species were illustrated for the first time.

The book was an opportunity for Bateman – the orchidophile – to show off the collection of living plants that he and his friends were amassing. In the tropics, to ferret out the rare, the exotic and the special, they employed collectors 'who, by their zeal and skill, have successively contributed to bring Orchis-growing to its present palmy state'.[111] The '*annus mirabilis* of Orchis-importatum' was 1837, when,

> In addition to the spoils brought by Mr GIBSON from the Nipalese Hills, and which reached Chatsworth in this year, Mr [George Ure] SKINNER poured into our stoves the richest treasures of the barrancas of Guatemala; – Mr [Allan] CUNNINGHAM sent a profusion of the choicest air-plants from the Philippine Islands; Mr [Richard] SCHOMBURGK contributed some exquisite species from the interior of Guiana; – and M. DESCHAMPS, a French, arrived with his vessel from Vera Cruz, entirely laden with Mexican Orchidaceae. In the whole, not less, probably, than three hundred species were seen in England for the first time in this memorable year.[112]

'Mr Skinner' was the English businessman George Ure Skinner, who serendipitously supplied Bateman and the commercial nursery firm Veitch & Son with Mesoamerican, mostly Guatemalan, orchids.[113] Tropical orchids continue to suffer the rapine attention of plant collectors who supply gardeners, intent on possessing, taming, controlling and ultimately caging nature, with the justification of being 'plant lovers'.

Selling the botanical world

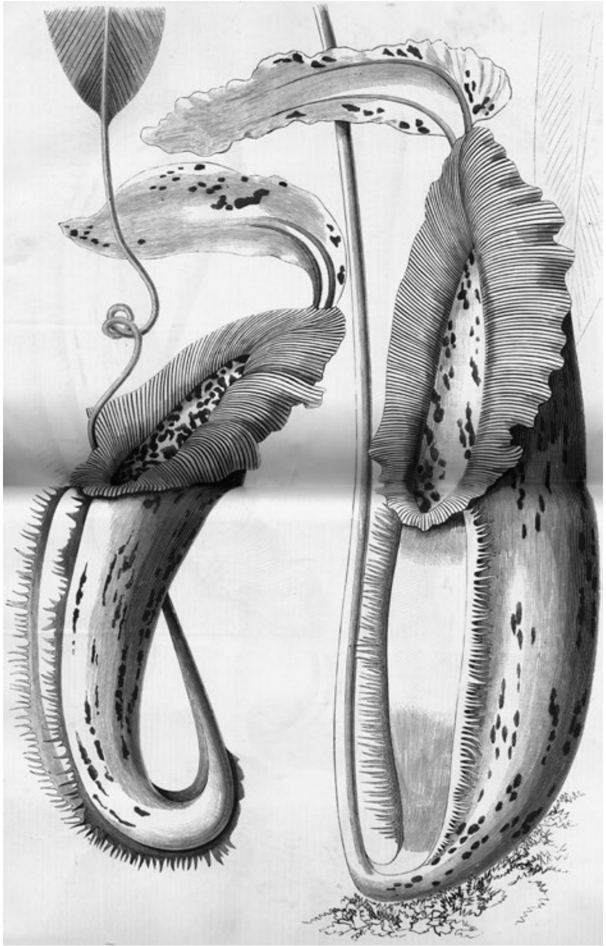
Plants growing in the gardens of the mighty and the wealthy may provoke envy and a desire among other people to own such plants. Advertisers know that the right image, in the right context, sells almost anything. In 1691 the English nurseryman William Darby of Hoxton, east of London, tempted his clients with a catalogue made up of herbarium specimens: 'a folio paper book in which he has pasted the leaves and flowers of almost all manner of plants, which make a pretty show, and are more instructive than any cuts in herbals'.[114] However, the potential of such an object – other than through its novelty – to sell brightly coloured garden flowers or fruit trees was probably limited.

The Dutch artist and nurseryman Emanuel Sweerts created his *Florilegium amplissimum et selectissimum* (A Very Large and Select Collection of Flowers, 1612), containing 110 engraved black-and-white plates, as an illustrated sales catalogue of the plants available in his nursery. However, many of Sweerts's engravings were copied from the Flemish engraver Johann Theodore de Bry's *Florilegium novum* (New Florilegium, 1611).[115]

In the horticultural marketplace, it is coloured illustrations that are likely to make the most impressive advertisements. The manuscript known as *Tradescants' Orchard*, traditionally associated with the seventeenth-century English horticulturalists John Tradescant father and son, has been interpreted as a trade catalogue for their nursery business.[116] In 64 pen-and-watercolour illustrations a range of fruit, among them plums and peaches, is displayed.

In 1731 Robert Furber issued one of the earliest nursery catalogues in Britain, a series of twelve metal-engraved plates called *Twelve Months of Flowers*, which were offered for sale by subscription at £1 5*s* (about £150 in 2022) uncoloured or £2 12*s* 6*d* coloured (about £310 in 2022).[117] Each plate, named after a month and drawn and engraved respectively by Pieter Casteels III and the English engraver Henry Fletcher, is a still life of seasonal flowers arranged in an elaborate vase. The flowers are all numbered for ease of identification and, presumably, ordering from Furber's nursery. Overall, more than four hundred different plants are represented.

On his return from North America, Mark Catesby worked with another London nurseryman, Thomas Fairchild of Hoxton, to promote



Pitchers of the endemic Sarawakian insectivore *Nepenthes northiana*, found on limestone mountains some 300 metres (985 ft) above sea level. The wood engraving, from *The Gardeners' Chronicle* (1881), is based on a painting Marianne North made in 1876. To collect the material, North's field assistant 'traversed pathless forests amid snakes and leeches'; 'only those who have been in such places can understand the difficulties of progress there.' When North was presented with the pitcher plants, she 'grumbled at having only one small half-sheet of paper left to paint them on'.[118]

the cultivation of North American trees in Britain: 'a small spot of land in America has, within less than half a century, furnished England with a greater variety of trees than has been procured from all the other parts of the world for more than a thousand years past.'[119] One of the most dramatic of these introductions was the southern magnolia with its glossy evergreen leaves and huge white flowers, shaped like a pair of cupped hands.

Following Catesby's death in 1749, the *Hortus britanno-americanus* (The British-American Garden, 1763) and *Hortus europae americanus* (The European-American Garden, 1767) were published under his name. These volumes were illustrated with small metal engravings of numerous North American species that might be suitable for British soils.[120] These poor images were abstracted and copied from Catesby's self-illustrated, folio-sized *Natural History of Carolina, Florida and the Bahama Islands* (1729–47).

Before a botanical illustrator starts work, they usually know whether the plant they are drawing is a new species. Sometimes an illustration is later discovered to represent a new species. In 1876 the British artist Marianne North was a guest of the White Rajah, Charles Brooke, in Sarawak, Borneo. For years North had been using her substantial private means and social connections to travel the world, painting plants in their natural habitats.[121] During that trip, she reported, her field assistant – Herbert Everett, a cousin of the Pre-Raphaelite painter John Everett Millais, 'as good as a book to talk to' and 'full of wit and information' – 'went up the Mountain near [Tegora] and brought me down some grand trailing specimens of the largest of all pitcher-plants, which I festooned round the balcony by its yards of trailing stems. I painted a portrait of the largest.'[122] Unknowingly, Herbert had discovered the leaves of a new species, which North illustrated.

When Harry James Veitch, head of the nursery James Veitch & Sons, saw North's oil painting, he realized that the plant might be new. Moreover, its novelty gave it commercial value among Victorian enthusiasts for insectivorous plants – who were almost as ardent in their demand for the unusual as their orchidophile colleagues. Eventually, in 1881, one of Veitch's men in Southeast Asia, the English botanist Charles Curtis, managed to return ripe seed and herbarium specimens of the plant safely to Britain.[123] At Veitch's request, North was commemorated when the species was formally named *Nepenthes northiana* by the director of the Royal Botanic Gardens, Kew, Joseph Hooker.[124] When Veitch's nursery offered North's pitcher plant for sale in 1883, the price – five guineas each (about £390 today) – reflected its rarity and a market tailored to those clients who possessed the specialized glasshouses necessary to cultivate this tropical trophy.[125]

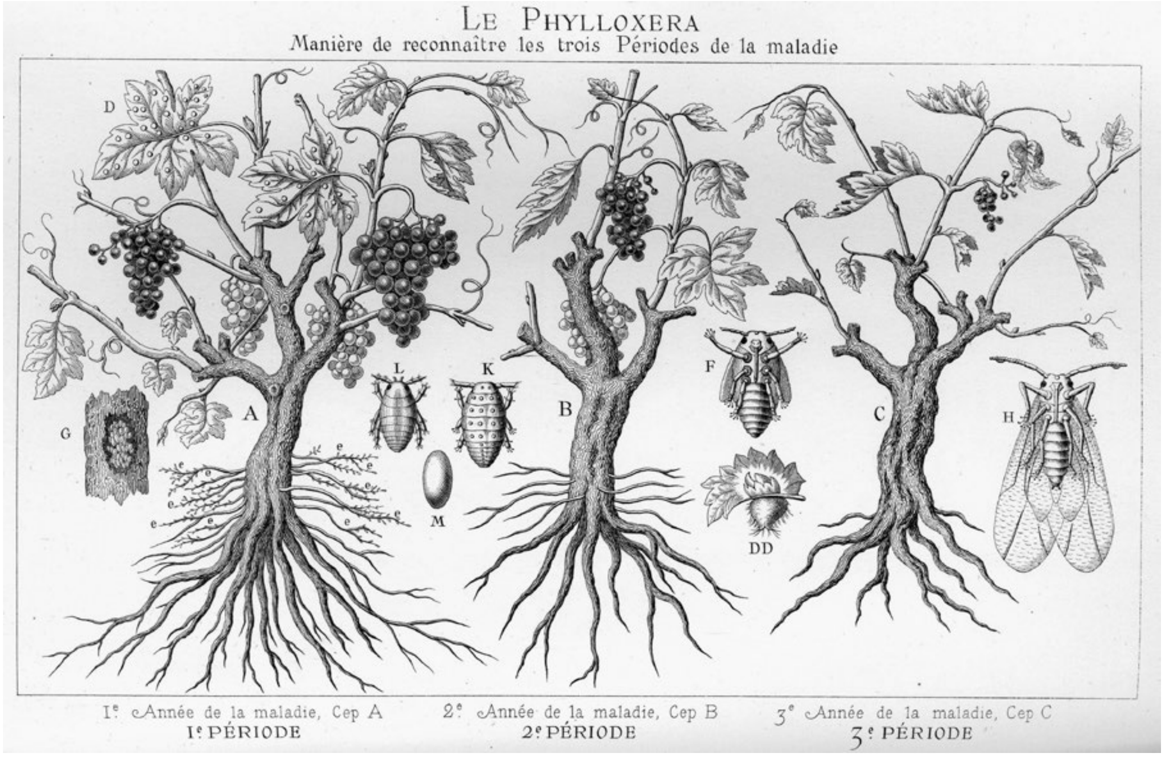
For most botanists and gardeners, though, North's pitcher plant was known only from Hooker's brief, formal Latin description and the accompanying black-and-white illustration copied from North's oil painting, which had given Veitch the idea that it was a new species. For it to be of use to his business, Veitch needed living plants, while dried specimens with flowers and/or fruit were essential if the species' novelty was to be confirmed and a formal description made.

In 1882 North's entire collection of 832 distinctive oil paintings was put on permanent public display in a gallery (today called the North Gallery) – 'barely capable of showing fifty to advantage'[126] – that she commissioned and financed at Kew. North's artistic style, composition and use of oils are rather too decorative for the taste of many botanists, but the visual impact of her works and the stories surrounding them mean that they have broad popular appeal.[127] However, her work continues to reveal new botanical discoveries. In 2021 a blue-fruited member of the coffee family, *Chassalia northiana*, was formally described from Sabah and Sarawak based on a herbarium specimen collected in 1987.[128] The species was one of a collection of plants included in North's painting 'Curious Plants from the Forest of Matang, Sarawak, Borneo', made in the 1860s. Once again, North was honoured for inadvertently delineating a new species.

Orchards and vineyards

Pomology, the study of fruit-growing, and Pomonae, those books devoted to fruit (especially apples, pears, plums, cherries, peaches and grapes) and their cultivation, derive their names from Pomona, the Roman goddess of fruit trees. Classical and pre-Renaissance authors and illustrators – among them David Kandel, with his idiosyncratic woodcuts for Hieronymus Bock's *New Kreüterbuch* (1539), and the maker of the decorative woodcuts in Pietro Andrea Mattioli's *Commentarii in sex libros Pedacii Dioscoridis* (1544) – attest to a long history of interest in fruit and fruit production among European botanists and gardeners.[129] The English garden designer Batty Langley's *Pomona; or, The Fruit-Garden Illustrated* (1729), an instruction manual aimed at garden owners interested in the business of maximizing the productivity of their orchards, illustrated with 79 black-and-white line-etched plates of hundreds of different fruit cultivars, proved popular.[130] Its inclusion of damaged leaves and blemished fruit shows that Langley used living plants as the models of each image, rather than relying on copying standardized structures across different figures. Furber's *Twelve Plates with Figures of Fruit* (1732) comprises twelve hand-coloured engraved broadsheets, based on paintings by Casteels, of more than 350 different fruit.[131] These plates were probably an example of Furber using a decorative catalogue for selling fruit, as he had done the previous year for garden flowers.[132]

The French naval engineer and botanist Henri-Louis Duhamel du Monceau's two-volume *Traité des arbres fruitiers* (Fruit Trees, 1768) set a new standard for what was expected of Pomonae.[133] His work focused on traditional French fruit, such as apples, cherries, plums and especially pears. Each named sort was described using a consistent set of features, and across the 180 hand-coloured engravings, fruit was illustrated together with leafy shoots and flowers – all evidently drawn from life. The plates were made by a team of engravers, including Catherine and Elisabeth Haussard, based on illustrations by Claude Aubriet, Madeleine Françoise Basseporte and René le Berryais. Basseporte, who was apprenticed to Aubriet, eventually succeeded him to the prestigious position of royal painter (*Peintre du Roy, de son cabinet et du jardin*), which she retained for nearly four decades.[134] Expanded editions of the *Traité* published in the early nineteenth century included the work of Pierre-Joseph Redouté and Pancrace Bessa.[135]



Black-and-white lithograph showing three different stages of phylloxera symptoms on European grape, and the life cycle of the responsible insect. The illustration, which first appeared in a Lyonnaise publication by the French viticulturalist Matthieu Charmet, was republished in the widely circulated nineteenth-century horticultural journal *Flore des serres et des jardins de l'Europe* (1873).

It was 'the opening years of the nineteenth century [that] were the Golden Age of pomology'.[136] This was the age when Pomonae became status symbols offering glimpses into horticultural diversity that could readily consume fortunes and fill the land and leisure of those with resources to spare. British Pomonae focused on apples, while French versions, the 'variety and excellence [of] which have never been surpassed', excelled at displaying pears and grapes.[137] Of these French works, some of the greatest superlatives have been reserved for Joseph Decaisne's nine-volume *Le Jardin fruitier du muséum* (The Museum's Fruit Garden, 1858–75): 'Of the colouring of the plates it is impossible to speak too highly; the lithographs are magnificent, and no pomological work has ever approached them for correctness of colouring. The drawing is of equal merit, and the wood and leaves of each fruit shown are indicated in outline with the greatest exactitude.'[138] More than five hundred of the lithographs are based on illustrations by Alfred Riocreux, 'the most sensitive and skilful French botanical artist of the period'.[139]

In 1815 the Horticultural Society of London employed the artist William Hooker to paint fruit varieties, and over the next eight years he

produced hundreds of works. In 1818 he published the *Pomona Londinensis*, a collection of 49 hand-coloured aquatint engravings of fruit. Moreover, the pigment he invented, Hooker's Green, proved particularly useful for depicting fruit, such as apples, pears and quince.[140] The secretary of the society, John Lindley, was also associated with the elaborately illustrated three-volume *Pomologia Britannica* (British Pomology, 1841), whose 152 hand-coloured metal engravings are based mostly on illustrations made by Augusta Withers when she was in her twenties.[141]

Pomonae could also be a useful means for nursery owners to advertise their stock to potential clients, as the Tradescants had shown in the seventeenth century. The Brentford-based nurseryman Hugh Ronalds's *Pyrus malus Brentfordiensis* (Brentford Apples, 1831), illustrated with 42 fine lithographed plates by his daughter Elizabeth, appears to be a subtle sales catalogue for more than 170 apple cultivars by 'assisting gentlemen and gardeners to form assortments in every respect suitable to the particular situations for which they may be required'.[142]

Rather than devices to provoke horticultural dreams, envy or sales, botanical illustrations also help to inform growers about improvements in cultural practices or the identification of pathogens. In the nineteenth century in the wine-growing regions of Europe, it was observed that vines were losing productivity as their leaves dried and died.[143] The cause of the condition, known as phylloxera, was eventually tracked down to the sap-sucking grape phylloxera bug, which had been introduced inadvertently from North America. In Europe, the discovery of a cure for, or at least a means of preventing the spread of, phylloxera became an economic necessity, especially in France. Part of any strategy was people, especially vine growers, being able to identify the condition and understand its cause. Clear illustrations contributed, as they have done for all the diseases that have broken out in horticulture, agriculture and forestry to the present day.

Changing gardens

It is a truism that gardens change constantly with the seasons and years. Subtle evolutionary changes are associated with such processes as the preoccupations of garden owners, the tastes of societies, and the availability of plants and technology. The inevitable selection of the marketplace and

horticultural fashion perhaps leads to the loss of diversity among flowers, fruit and vegetables. More dramatic are revolutionary changes that may lead to little more than the survival of the remnants of walls, border outlines and perhaps an occasional long-lived tree. Gardens – whether grand or not so grand – may even disappear, leaving little or no trace of their existence except illustrations.

The gardens of Cannons, a magnificent early eighteenth-century stately home near Edgware in north London, was built for the English politician and patron of the arts James Brydges, 1st Duke of Chandos.[144] Brydges's fortune, made from his public appointments, was diminished significantly when the slave-trading South Sea Company became entangled in the South Sea Bubble. However, he continued to live beyond his means, building vast debts that, within years of his death, forced his son to raze Cannons and its gardens in a demolition sale.

In contrast, actions associated with garden destruction may have long-term cultural and political consequences.[145] By the end of the Second Opium War (1856–60), the complex of Yuanming Yuan covered an area approximately five times that of the Vatican today.[146] Its destruction, which took thousands of troops days to achieve, was a retaliatory action ordered by the British High Commissioner to China, James Bruce, 8th Earl of Elgin. One active participant, 27-year-old Captain (later General) Charles George Gordon, claimed it 'made one's heart sore' and 'you can scarcely imagine the beauty and magnificence of the places we burnt'; although he 'could not plunder them carefully', he considered he had 'done well' from his booty.[147] However, the absence of detailed records makes determining the specific planting of these imperial gardens a challenging research project.[148]

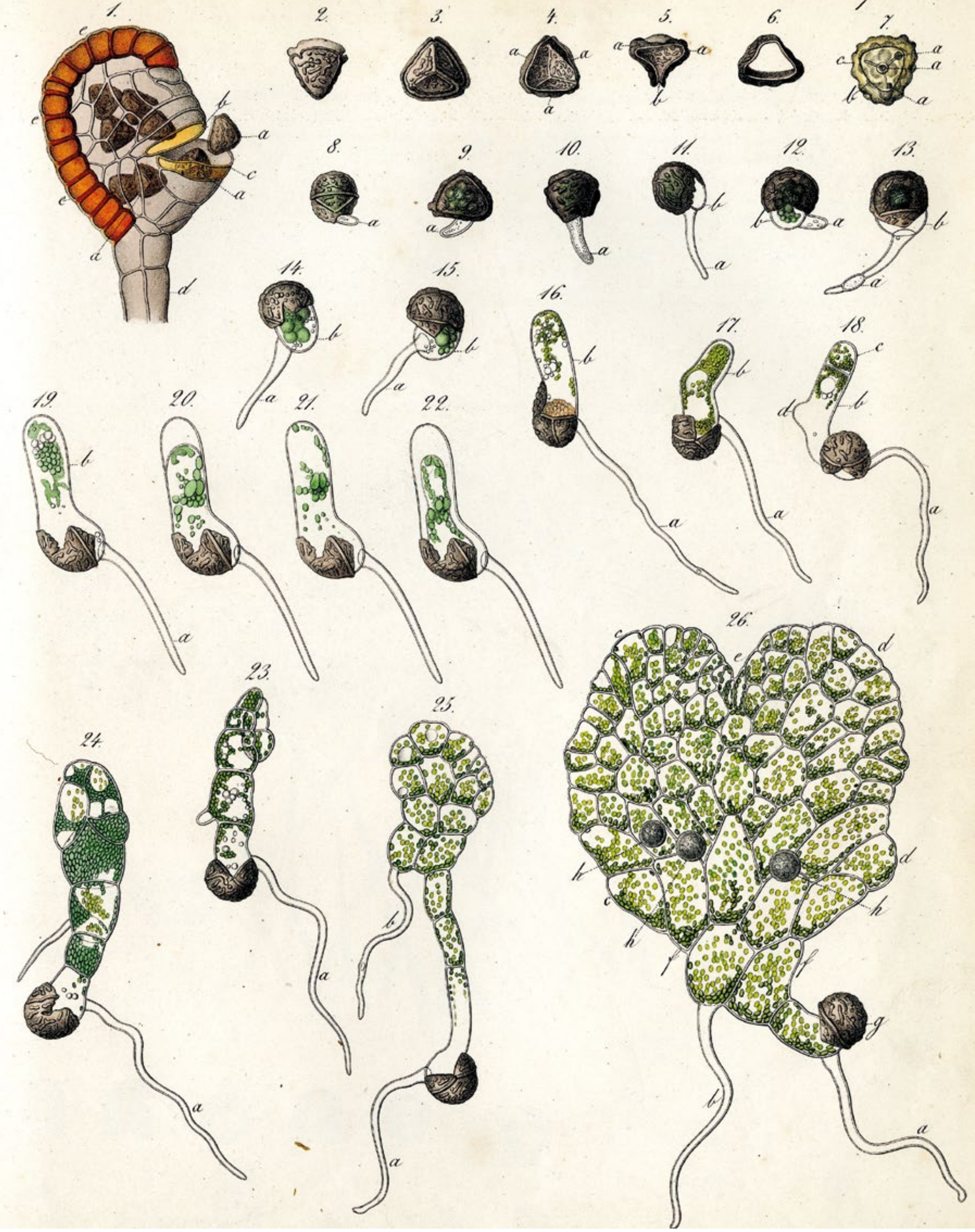
The gardens of John Gerard and John Parkinson, which disappeared beneath urban development long ago, are known from their catalogues, illustrated with borrowed woodcuts.[149] Destroyed gardens whose contents are known from florilegia include those of the prince-bishop of Eichstätt, which was abandoned in the teeth of the Thirty Years War (1618–48), and of James Sherard at Eltham. In the latter case, many of the rare plants were transferred to specially built conservatories in the Oxford Botanic Garden, where Johann Jakob Dillenius took up the position of first Sherardian Professor of Botany (established by James's elder brother, William).

However, 150 years later lack of money forced another sort of horticultural change as the surviving plants were transferred to an unknown fate at Kew.[150]

The North American and Chinese activities of such nineteenth-century collectors as David Douglas, Archibald Menzies and Robert Fortune transformed the appearance of European gardens and forests.[151] Today's gardens, filled with the products of global horticultural collecting, are important places for botanical illustrators. Skilful artists have portrayed horticultural introductions for purposes that include documenting plant diversity and the triumphs of collectors or garden owners, and reaping commercial rewards from botanical novelty. In some cases, plants taken from the wild have become global horticultural treasures, garnering immense profits through international trade. In other cases, collecting from the wild has driven wild plant populations to the verge of extinction, introduced species that have become weeds, or led to the establishment of serious plant diseases. Moreover, the triumphalism associated with accounts of the introduction of garden plants does not sit well with present-day concerns for conservation, the spread of disease and the exploitation of local peoples.

PLANT COLLECTORS, whose activities sometimes become associated with tales of adventure and bravura, have sent seed and living plants back to Europe. Much material failed the test of being a 'good garden plant', but sometimes novelty introduced from the wild was moulded into even more novelty as gardeners sought to make 'better' plants. These experiments in the selective pressures associated with disease, commerce and indifference have been recorded in illustrations. In today's public gardens, plants surviving the vicissitudes of time may be given special status as directors vie for visitors. Evidence of the age of these plants comes from botanical illustrations, while florilegia may contribute to the re-creation of so-called lost gardens.

Taf. I.



six

INSIDE AND OUT

> An accurate copy, although it be very roughly executed, has an aspect of truth which is unmistakeable, while a drawing which is the offspring of the imagination instead of a simple copy of nature, bears the mark of untruth in every line, however elaborate and unexceptionable its execution may be.
>
> LIONEL SMITH BEALE, *How to Work with the Microscope* (1868)[1]

Spore-producing structure (sporangium) from the underside of ribbon-fern fronds from the Polish botanist and art collector Michał Hieronim Leszczyc-Sumiński's investigation of fern development in 1848. Leszczyc-Sumiński's illustrations, made into hand-coloured lithographs by Carl Friedrich Schmidt, show the sporangium structure (top left) and microscopic details of the spore germination and embryo development in the fern's life history.

A student of the Swedish naturalist Carolus Linnaeus, the physician Johannes Roos, wrote a dissertation likening the natural world to a vast, multi-vaulted museum.[2] The largest rooms were public, open to all, but innumerable tiny rooms were locked, accessible only to specialists with the skill, and luck, to discover the keys.

The Renaissance artists Leonardo da Vinci and Michelangelo discovered a key to a medium-sized room, which could be labelled 'naturalistic reproduction of human form', through illegal anatomization.[3] As the skin parted beneath their respective knives, layers of ignorance were peeled away, revealing the precise manner in which ligaments and muscles are attached to articulated arrangements of bones in the skeletal scaffold. Such knowledge, together with their prepared minds, helped these Florentine artists depict, with confidence, manifold naturalistic postures of the human body. Yet neither man needed to understand the function of what they observed in order to represent realistic human forms.

Knives and the unaided eye unlock some rooms, but many may be entered only with keys made of more subtle dissection tools, supplemented by enhanced vision. In 1625 Galileo Galilei submitted his 'little eye', a compound microscope, to the Accademia dei Lincei in Rome. Instruments

working on similar principles had been developed by spectacle makers in Holland from the late sixteenth century onwards, based on simple lenses that had their origins in ancient Near Eastern cultures.[4] The underlying principle of the microscope is that an objective lens magnifies an object, the image of which is focused using an eyepiece lens. The simplicity of the principle belies the craftsmanship, complexity and optical sophistication necessary to make high-quality lenses, and hence images. The microscope was Roos's key to the smaller museum rooms – the *mundus invisibilis* (invisible world) – which he entered without a guide.[5]

Robert Hooke went further, even suggesting that the microscope could overcome human imperfections:

> By the addition of such artificial Instruments and methods, there may be, in some manner, a reparation made for the mischiefs, and imperfection, mankind has drawn upon it self, by negligence, and intemperance, and a wilful and superstitious deserting the Prescripts and Rules of Nature, whereby every man, both from a deriv'd corruption, innate and born with him, and from his breeding and converse with men, is very subject to slip into all sorts of errors.[6]

The eighteenth-century English optician and instrument maker George Adams asserted a similar view, that using the microscope to investigate plant anatomy was a 'duty to encourage every humble effort towards the advancement of science', and at the same time 'promoting that vast plan to which all things are now converging, the bringing all his [God's] creatures to a state of truth, goodness, and consequent happiness, an end worthy of the best and wisest of beings'.[7]

Recording and making sense of the new world revealed to the aided eye are different from merely looking through a lens and being amazed by what is revealed. If general conclusions were to be drawn, ways of looking had to be discovered that ensured observations were specific to neither instrument nor observer – that is, that they were repeatable and not merely artefacts. Moreover, the world revealed by the lens had to be communicated, and therefore depicted with accuracy by natural-history illustrators. Just like Leonardo and Michelangelo, as illustrators built their observational skill they brought knowledge to the depiction of their subjects, even if those

subjects existed only as fragments.[8] This chapter focuses on the ways in which botanical illustrators have worked with naturalists to present the new worlds made visible through magnification using simple hand lenses or the compound microscope. As our tools become more sophisticated and reveal ever more detail, illustrations continue to increase our understanding of plant biology and our appreciation of the aesthetics of the 'invisible'.

Drawing microscopic objects

The Victorian physician Lionel Smith Beale, Professor of Physiology and General and Morbid Anatomy at King's College, London, made a forthright case for the value of illustrations made under the microscope:

> it may be truly said that no real advance in our knowledge of the minute structure of animal or vegetable tissues, can be communicated to others, unless accurate drawings are made, for it is almost hopeless for an observer to attempt to describe what he sees in words . . . On the other hand, a truthful drawing . . . may be compared with drawings which may be made a hundred years hence, and although the means of observation will be far more perfect than they are at present, such comparisons may be useful.[9]

This was a familiar theme for Beale; he had made similar points in 1857, in his founding editorial for the *Archives of Medicine*: 'drawings . . . take the place of description as far as possible.'[10] However, he recognized the financial burden of the principle: 'it is hoped that ere long . . . free illustration will be carried to a still greater extent.'[11]

Whether light is reflected from or transmitted through an object magnified by simple lenses or the microscope, botanical illustrators are faced with three challenges. First, they must get the best performance out of the technology, and understand its limitations. Second, they must determine what is presented to the aided eye, and finally, they must decide how to present the observed image in a form that can be understood by the intended audience.[12]

Performance is influenced by the quality of microscope lenses, the ability to focus light and the methods used to prepare objects for investigation.

Some objects can be viewed whole; others must be cut into very thin slices, perhaps stained, then mounted on glass slides before they can be examined and drawn.[13] Preparation, such as preservation and staining, distorts what is observed. Moreover, only a small part of the object is visible under the microscope, making it necessary to refocus the image several times to gain a complete impression, and forcing the observer to stitch together separate images. One begins to get a sense of the challenge by remembering that childhood game where the identity of a familiar object must be discovered from seeing only part of it, either magnified or from an unusual angle. With the naked eye, a nettle leaf appears to have a few stiff, upright hairs. Under a low-power magnifying glass, the hairs become a tangle. As magnification increases, the structure and character of individual hairs start to be resolved.

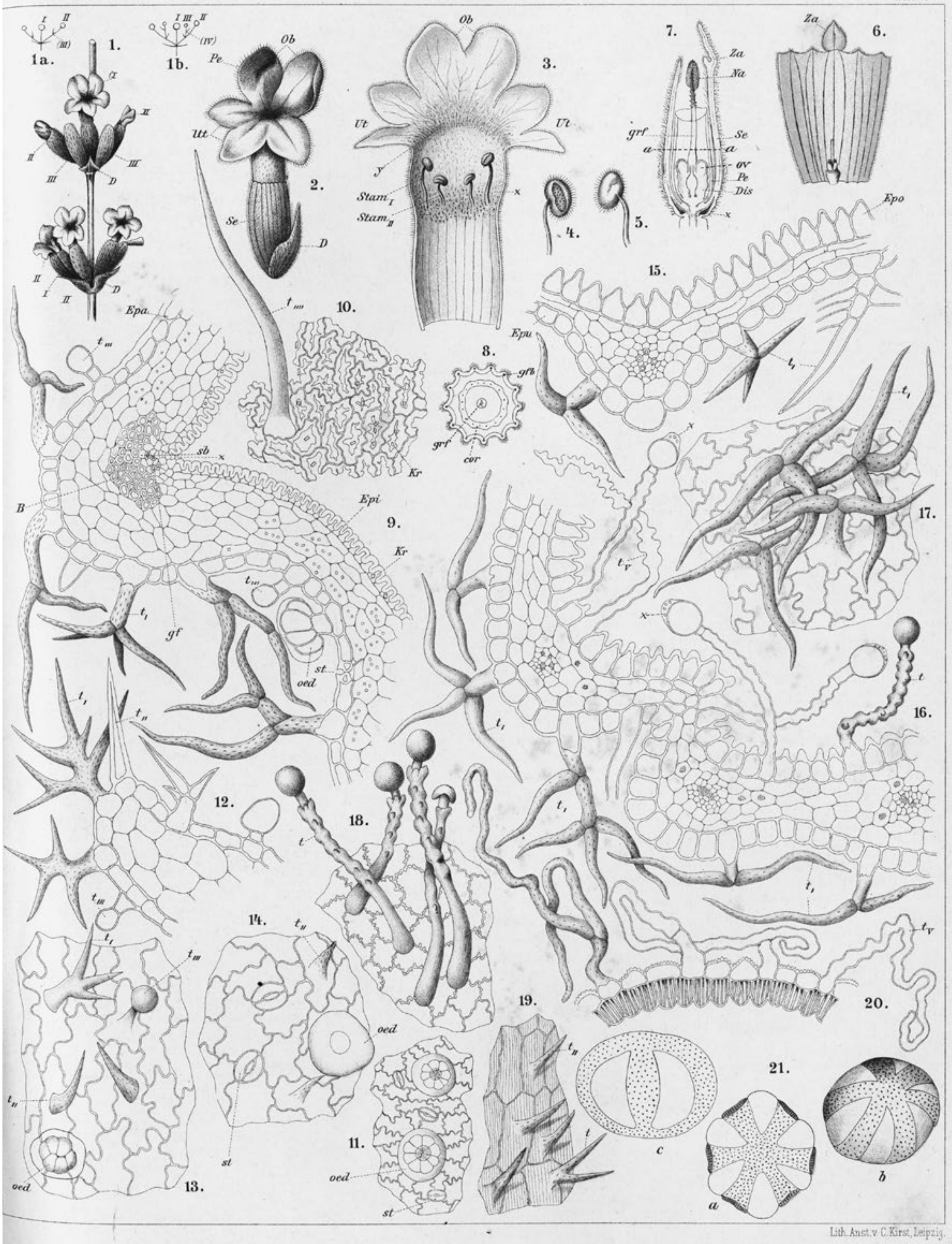
Drawing accurate, correctly scaled images under the microscope does not come naturally; the observer must train themselves. A simple method is to look through the microscope with both eyes open: one eye looking through the eyepiece, the other following the line a pencil traces on paper. During the nineteenth century mechanical devices of all kinds, among them *camerae lucidae* and reflectors, were invented as additional aids to the illustrator.[14] Some writers encouraged naturalists using the microscope to go beyond drawing on paper, by drawing directly on boxwood for wood engraving or on stone for lithography, since it was unreasonable to expect a craftsman to look 'at specimens in a microscope, observing things which he neither knows nor perhaps desires to know anything about'.[15]

Early illustrators of microscopic objects were pioneers, exploring without the benefit of frames of reference, comparative illustrations or even the language to describe what they saw. It is little wonder that viewers of magnified botanical illustrations might disbelieve the evidence of their own eyes, perhaps questioning whether lenses were revealing artefacts of object preparation or monsters of illustrators' imaginations.

Invisible worlds

The world revealed by the pioneering Dutch microscopist Antonie van Leeuwenhoek in a drop of pond water trapped between two pieces of glass was easy to explore because no complex preparations were necessary.[16]

Lithograph showing the magnified appearance of the dried drug 'Flor. lavandulae'. This illustration of dried lavender flowers, published in Leipzig, was part of Alexander Tschirch and Otto Oesterle's *Anatomischer Atlas der Pharmakognosie und Nahrungsmittelkunde* (Anatomical Atlas of Pharmacognosy and Food Science, 1900). The manual used the microscope to demonstrate the range of structures apothecaries might expect to see as they examined raw drugs for their quality.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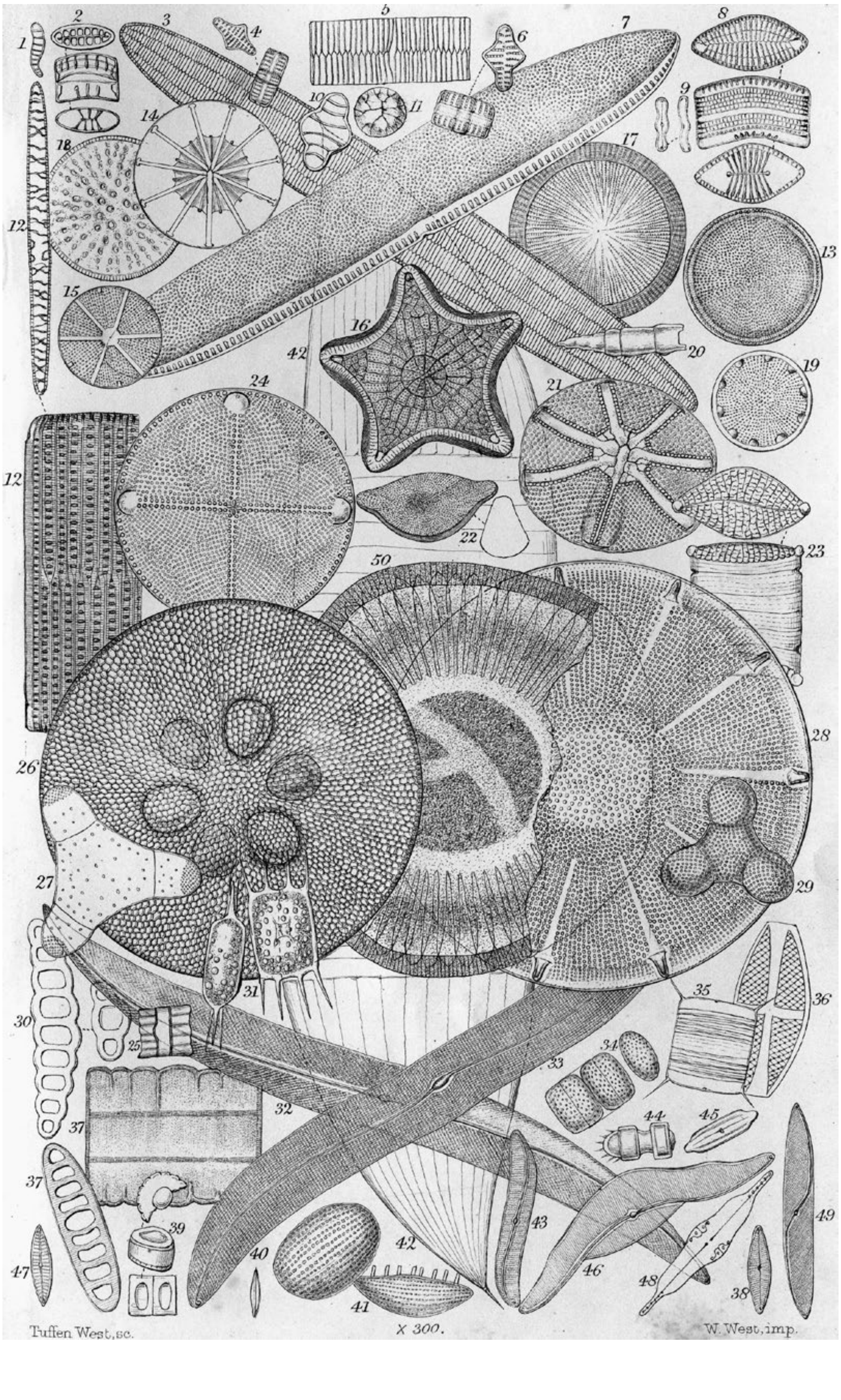
In 1861 the London-based optician and natural-history dealer Andrew Pritchard published the fourth edition of his *History of Infusoria*, a paean to the microscopic life teeming in this 'invisible' aquatic world.[17] Hundreds of 'wheel animalcules' (rotifers), protists, single-celled algae and diatoms were crammed into forty monochrome and hand-coloured metal-etched plates. Such plates both reveal the diversity of microscopic life in water and, together with more than 1,000 pages of text, provide the opportunity to compare individual species.

Diatoms are unicellular organisms, traditionally treated as plants, which are found anywhere there is water on the planet.[18] They are tiny, typically 0.002–0.2 millimetres (less than 1⁄64 in.) long, elaborately shaped pillboxes with walls primarily made of glass (silica). Moreover, they are major parts of global food chains, and essential for monitoring past and present environments. Fossil diatoms tens of millions of years old can form vast deposits of diatomaceous earths, tens of metres thick, which are used by humans for purposes as diverse as water filtration, explosives and toothpaste.

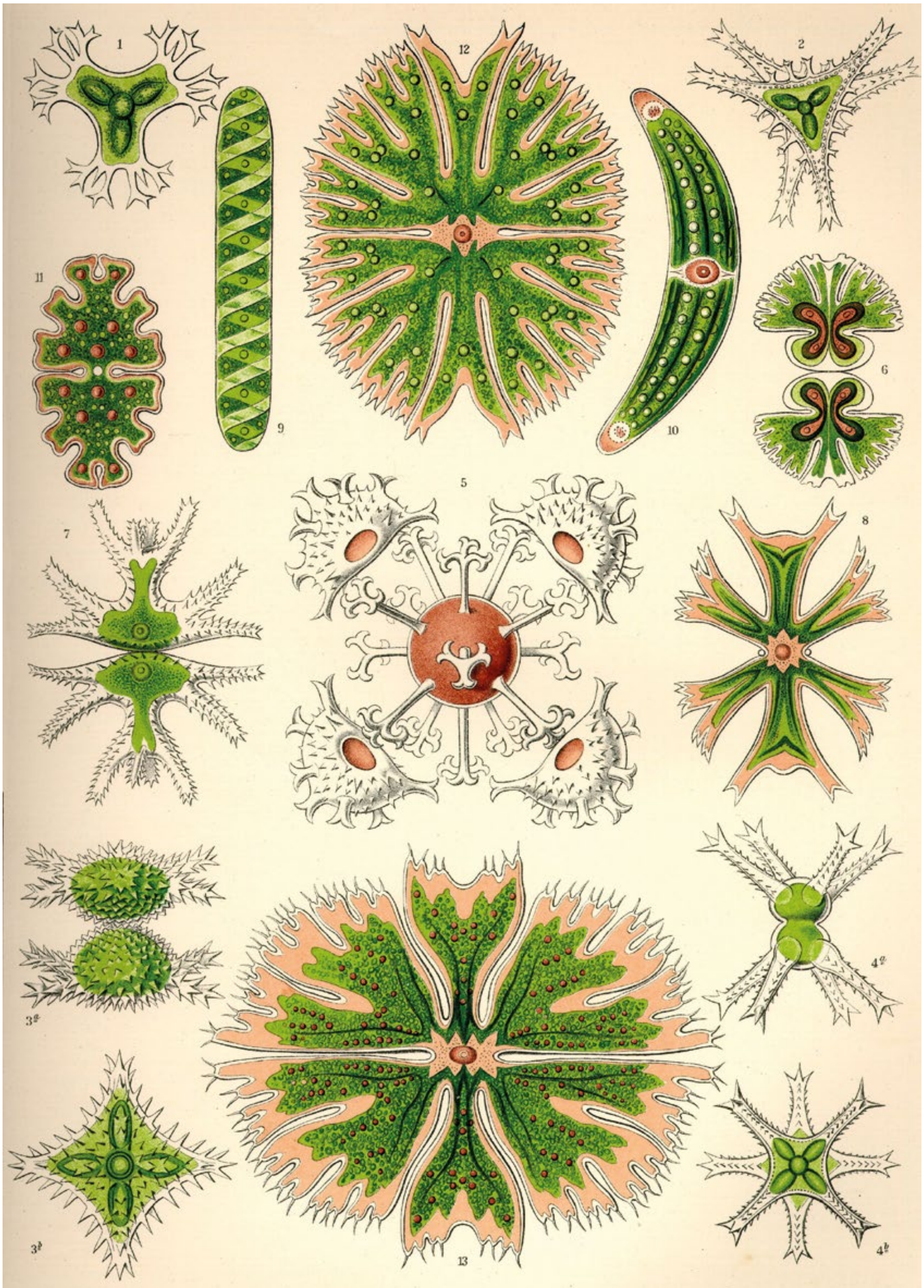
Variation in shape among diatoms is visible without the elaborate preparation of water samples. Surprisingly, given this and their global ubiquity, the first diatom was not described formally until 1782.[19] However, to see diatoms at their best, they must be cleaned by being burned or boiled in strong acid to destroy their insides. Their glass carcasses, called frustules, are then mounted in resins so that the silica walls become easily visible under the microscope. The effects are dramatic, and this led to diatoms becoming a standard item of interest to Victorian microscopists.[20] Moreover, it was discovered that the sizes of different diatom species and the separations of lines and punctures on frustule surfaces within species were remarkably constant. This meant the illustrator could determine the resolution of the lenses they were using in their microscope – and therefore the limits of what they could be expected to see. Moreover, the inclusion of diatoms in a preparation meant there was a ready scale by which to measure the objects being illustrated. Diatoms had become natural scales and frames of reference, providing confidence in both the comparability of illustrations and the scientific results being reported.

The German zoologist and natural-history illustrator Ernst Haeckel coined such familiar biological terms as ecology and phylogeny in the

Collection of diatom frustules, all at 300x magnification, from Andrew Pritchard's *History of Infusoria* (1861). Tuffen West's engraving may be based on his own original drawings, since his 'success as an engraver of microscopic objects' was associated with 'the interest he takes in the subject, and . . . his being himself a practical microscopical observer'.[21] A wide range of centric and pennate diatoms, together with their surface sculpturing, are represented in this complex plate. The patterns drawn by West are limited by the way they were mounted for the microscope and the quality of the lenses available to visualize them.



Tuffen West, sc. X 300. W. West, imp.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nineteenth century.[22] As a strong advocate of social Darwinism and because of the persistent claims of scientific fraud associated with the embryological images with which he illustrated his research, Haeckel has become an uncomfortable figure in modern biology.[23] But between 1899 and 1904 some one hundred of his illustrations, lithographed by Adolph Giltsch, were published as *Kunstformen der Natur* (Art Forms in Nature). These illustrations of microscopic life soon escaped from under the objective lens to become aesthetically powerful images that permeate popular culture today.

Sticks made from boxes

Stereotypically, plants are sticks rooted to the spot, adorned with leaves and ephemeral reproductive structures. Robert Hooke christened the cell, while Johann Moldenhawer showed the plant's entire structure to be made from them. Simplistically, plant cells are like boxes, made from different densities of cardboard, containing water-filled balloons. The denser the cardboard or the more water in the balloon, the more rigid the box. Reduce the amount of water in the balloon and the flexibility of the box increases; that is, the plant begins to wilt, deforming its shape. The way in which a plant deforms is a consequence of how cells are arranged in its body, how they are packed together and how their walls are thickened.[24]

Unlike Hooke, who was interested in plants as subjects for microscopy, his contemporary the English physician Nehemiah Grew was fascinated by plants for their own sakes. He was a physiologist who wanted to discover how plants grew, fed, moved and reproduced. Moreover, he thought that by understanding plants, he might also gain understanding of animals, since they both 'came at first out of the same *Hand*, and were therefore the *Contrivances* of the same *Wisdom*'.[25] In order to pursue these interests, Grew was convinced he had to know what stems, roots, leaves, flowers, fruit and seeds looked like on the inside, as well as the outside. As for Roos two generations later, the key to Grew's investigations was the microscope. In 1682 the Royal Society of London published his magnum opus, *The Anatomy of Plants*, which included 83 fine copperplate engravings of his own illustrations showing what he saw through a magnifying glass and a microscope.

The anatomical sections presented by Grew are not portraits; they are too perfect, too symmetrical, too uniform. Rather, they are ideals

Collection of microscopic algae from Ernst Haeckel's *Kunstformen der Natur* (1899–1904). Adolph Giltsch's lithograph of Haeckel's original illustration shows organisms from different places, at different magnifications, including the algal genera *Closterium* (10), *Micrasterias* (6–8, 13) and *Staurastrum* (1–5). Each stylized and formalized image is highly graphic, being laid out with great attention to the symmetry of the plate.

– diagrammatic summaries – the product of hours of observations made while trying to interpret what a pool of light and a pair of lenses revealed to him. Grew described his method of displaying information:

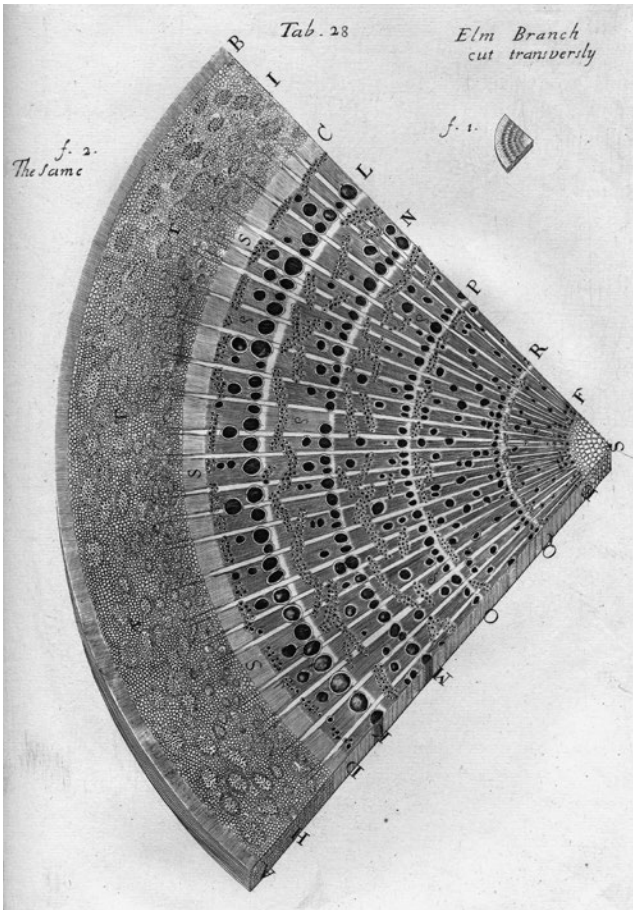
> In the *Plates*, for the clearer conception of the *Part* described, I have represented it, generally, as entire, as its being magnified to some good degree, would bear. So, for instance, not the *Barque*, *Wood*, or *Pith* of a *Root* or *Tree*, by it self; but at least, some portion of all three together: Whereby, both their *Texture*, and also their Relation one to another, and the *Fabrick* of the whole, may be observed at one *View*, Yet have I not every where magnify'd the *Part* to the same degree; but more or less, as was necessary to represent what is spoken of it . . . Some of the *Plates*, especially those which I did not draw to the *Engravers* hand, are a little hard and stiff: but they are all well enough done, to represent what they intend.[26]

He was experimenting with how to present information from a scale with which most of his audience was unacquainted. The presentation and interpretation of scale remain challenging in plant sciences to the present day.

Today, with nearly 350 years of accumulated knowledge about plant anatomy at our disposal, it is difficult to appreciate the reactions to Grew's images. However, his work, together with that of the Italian physician Marcello Malpighi – in the two-volume *Anatome Plantarum* (1675, 1679), illustrated with 93 copper-plate etchings and also published by the Royal Society – inspired people and formed the foundation for modern plant anatomy.[27]

Form with function

Leonardo's sketches of plants, and their incorporation into finished works, reveal the artist's attention to the form of plants as they grow in nature.[28] They also show his attention to patterns in nature. Following a journey through Italy between 1786 and 1788, Goethe, as had other writers before him, recognized patterns in the development of plants: 'we have sought to derive the apparently different organs of the vegetating and flowering plant from one organ: that is, the leaf.'[29] Leaves are not arranged higgledy-piggledy



Nehemiah Grew's reconstruction of a transverse section through a five-year-old elm branch, presented as a copperplate engraving in his *The Anatomy of Plants* (1682). This is one of thirteen plates of transverse sections through branches of woody plants. In each case, the section is shown as it appears to the naked eye and under the microscope. In his discussion of the relationships between wood anatomy and timber properties, Grew directs his readers to the relevant numbered plates so that they can see for themselves the comparative anatomical data from which he is drawing his conclusions.

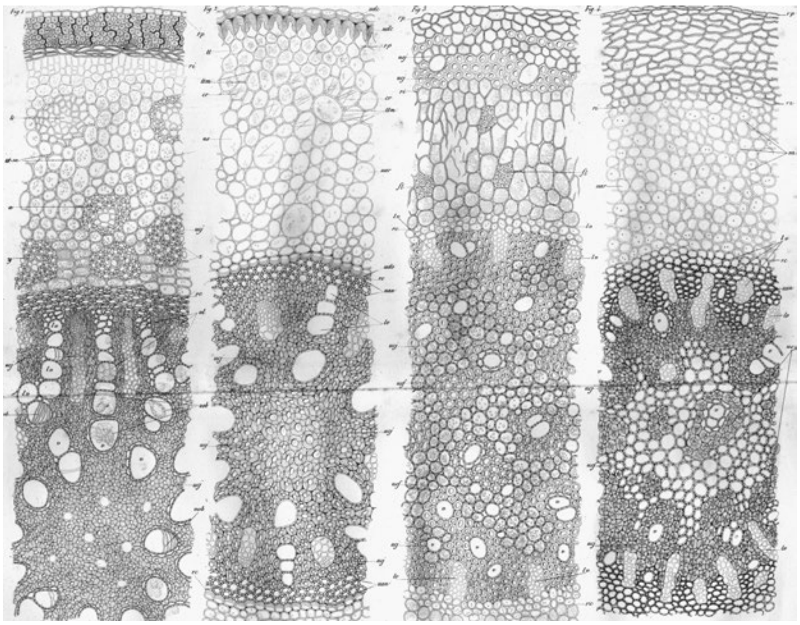
along a stem. The tiny flowers that make up the head of a sunflower are not randomly assembled. There is a pattern to the scales that make up a pine cone or the fruit of a pineapple.

To discover the patterns that make up the structure of a plant may mean looking inside. However, to understand the relationships among the revealed parts, it is necessary to make accurate illustrations. Imagine four ripe tomatoes with their green stalks uppermost. Slice one through the centre from stalk to base. Slice the second through the middle at right angles to the stalk–base axis. Slice the top off the third, and slice the fourth fruit through the middle at 45 degrees to the stalk–base axis. What do the cut surfaces look like? Imagine trying to understand and reconstruct the structure of the tomato without being able to see the whole of it. This is analogous to the problem botanists face when they examine microscopic sections through plant parts: appearances change depending on how the structures are sliced. Revealing internal structures requires cutting thin sections of tissue, using a steady hand and a razor blade, 'cutting engine' or microtome, then applying tissue-specific stains.[30]

Grew's seventeenth-century stylized images of magnified transverse sections through tree branches showed how different tissues were arranged and how that varied among species, revealing a new world of detail and patterns that naturalists learned to interpret. By the nineteenth century academic journals, such as *Transactions of the Linnean Society*, *Journal of Botany* and *Mémoires de l'Académie des sciences de l'Institut de France*, were replete with exquisite illustrations of sections through plant parts of different species, revealing such subtleties as the thickening of cell walls. Moreover, illustrations of anatomical structures became essential for researchers to communicate their discoveries to their peers and to convince naturalists about the veracity of their observations. The French plant

cytologist and anatomist Charles-François Brisseau de Mirbel was able to show that not only were all plant cells surrounded by a wall, but they all had a membrane just inside that wall.[31]

Peoples around the world have discovered that trees provide natural materials of great utility and economic value, and indeed European colonial expansion was partially associated with the search for high-value timber. Specific timbers are used for charcoal and firewood. Cork is harvested from the bark of the Mediterranean cork oak, while Native North Americans use paper-birch bark for applications as diverse as basket and canoe making.[32] In Britain, yew wood is the natural choice for bowyers making longbows; the elastic sapwood performs well under tension, while the heartwood performs well under compression.[33] Wheelwrights became experts at exploiting the mechanical properties of dozens of different types of wood to construct carriage wheels.[34] Those who undertook expeditions of economic exploration, such as that of the Prussian naturalist Peter Simon Pallas through the Russian Empire in the late eighteenth century, occasionally made illustrations of the external appearance of timber blocks, but these were hardly suitable for the purposes of understanding how form related to the timber's mechanical properties.[35] Comparative studies of minutely recorded distributions of water-conducting xylem (as wood), sugar-conducting phloem (as bark) and the growing cells of the cambium



Transverse sections (left to right) through the aerial roots of comb-leaf philodendron, vanilla, pandan and dragon tree. These comparative illustrations were made in 1842 by the French plant cytologist and anatomist Charles-François Brisseau de Mirbel. They show the quality of the lenses and the preparation of the specimens, and the ability of the illustrators to capture accurately what they see under the microscope, in the first half of the nineteenth century. The image was 'engraved on stone' by a lithographer called Laplante and printed by the Parisian lithographer Lemercier Bénard & Compagnie.

Planed vertical faces of blocks of economic, or potentially economic, timbers. The German naturalist Peter Simon Pallas, invited by Catherine the Great to the St Petersburg Academy of Sciences, undertook two expeditions in the Russian empire (1768–74, 1793–4). The Russian artist Karl Friedrich Knappe prepared the original illustrations for Pallas's *Flora Rossica* (1784, 1788), either on the expedition or in St Petersburg; the plates were engraved in Nuremberg and Vienna.

(the layer between the xylem and phloem) offered the possibility of understanding the basis of wood's various properties.

When the English polymath John Hill published *The Construction of Timber, from Its Early Growth* (1770; second edition 1774), he had it illustrated with 43 metal engravings, of which 26 showed cross-sections through pieces of wood from different species.[36] Hill's aim was

> to shew the Construction of Timber: the Number, Nature, and Offices of its several parts; and their various arrangements and proportions in the different kinds: To point out a way of judging, from the structure of Trees, the uses which they will best serve in the affairs of life; and of adding something to their strength, and preservation.[37]

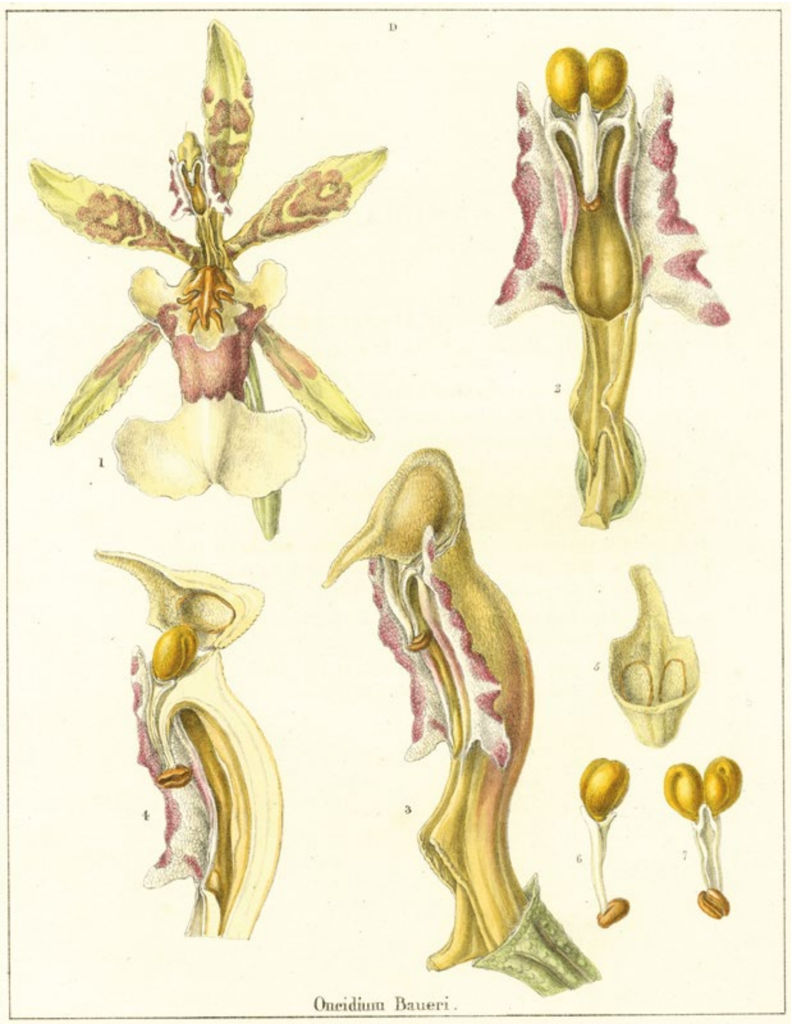
A magnified cross (or transverse) section of a piece of wood looks rather like a box of straws seen from above. However, this belies the three-dimensional nature of wood, which is revealed when the grain of a piece of timber is examined. Comparative wood anatomy – where it was necessary to compare unambiguously two-dimensional sections in order to reconstruct three-dimensional wood blocks – exposed the limitations of botanical illustrators. The detail of this new world was initially depicted by these artists, but coupling cameras with microscopes in the late nineteenth century enabled anatomical sections to be rendered with both ease and accuracy. As the technology developed, photographic images became more complex, and from the mid-twentieth century cameras were connected to electron microscopes. However, the skill of botanical illustrators as editors of scientific images comes to the fore when they collaborate with scientists to help viewers separate the essential from the inessential.

Infinity of modifications

Diversity of orchid form, colour and habit fascinates us; our homes, glasshouses and mythologies abound with these complex flowers. Moreover, those who discover new orchids often want to keep their locations secret, lest such places be depredated by those keen to augment their personal collections.[38] Such qualms rarely afflicted botanists before the late twentieth century, however. In November 1836 George Gardner spotted the large rose-coloured flowers of *Cattleya labiata*[39] on the sheer sides of Pedra da Gávea, a monolith rising high above Rio de Janeiro, claiming that 'Gavea will long continue to vegetate, far from the reach of the greedy collector.'[40] A few days later he had no qualms about collecting enough of the orchid, from a more accessible site, to allow him to ship living plants back to the glasshouses of his British sponsors.[41]

Franz Bauer – originally from Moravia in the Czech Republic – 'attained a most deserved celebrity' after settling at Kew in 1790.[42] He effectively remained under the patronage of the powerful English naturalist Joseph Banks for the rest of his life, as 'Botanick painter to His Majesty [George III]'. With the largesse and security offered by Banks, and royal patronage, Bauer made vivid records of the exotic plants being raised by the monarch's skilled gardeners, and was free to pursue his own botanical interests. After his death, one of his friends commented that his illustrations 'united the accuracy of the profound naturalist with the skill of the accomplished artist to a degree which has been only equalled by his brother Ferdinand[,] and in microscopical drawing he was altogether unrivalled.'[43]

Oncidium baueri with a 'flowering stem from six to seven feet high', 'grown at the [King's Road] nursery of the late Mr Colvill[e]' from *Edwards's Botanical Register* (1833).[44] Sarah Anne Drake's watercolour was converted to a metal etching by J. Watts, and hand-coloured and published by J. Ridgeway on 1 February 1834. John Lindley was confused by *O. baueri* and *O. altissimum*, a problem that was resolved only when he saw the two species growing together in the 'stoves of Messrs Loddiges' nursery in Hackney in 1836.



Floral dissection of the Caribbean and South American orchid *Oncidium baueri* from Franz Bauer and John Lindley's *Illustrations of Orchidaceous Plants* (1830–38). Maxim Gauci's lithograph of the eponymous orchid, named by Lindley in honour of Bauer, is based on Bauer's watercolour from 1804. Remarkably, Bauer accurately reconstructed, and coloured, the flower from a dried specimen. The numerous views (with magnifications ranging from 4x to 16x) enable the viewer to see the three-dimensional details that are essential for separating this species from the many other species in the genus.

Bauer had studied orchids since arriving in England. He looked beyond the superficial beauty of these flowers, to speculate about how his subjects lived. He pulled them apart and cut them into pieces so that he could study their morphology and anatomy under the microscope. As his knowledge and understanding increased, he began to ask questions about what he saw, making conjectures about what he observed.[45] As did Hooke, Bauer took what he saw under the microscope and interpreted it in pencil, ink and watercolour in ways that others could appreciate. However, he published few of the many images he produced so painstakingly.

Unlike his brother Ferdinand, Franz rarely ventured into the field for his subjects. Rather, he relied on gardeners to bring plants in prime

condition from Kew's glasshouses to his studio. These botanical riches had been harvested from across the globe by men engaged by Banks and his colleagues in the imperial project to fill the monarch's gardens with vegetable novelties and rarities for the potential benefit of the British Empire. In the first years after its foundation in 1759, technical problems limited the diversity of plants at Kew. The long-distance transport of living plants was rectified by the invention of the Wardian case in the 1820s. The ability of Kew's glasshouses to mimic exotic environments was improved by technology that enabled the effective control of temperature and humidity.[46] Bauer's investigations of orchids benefited from these changes, together with technical improvements to microscopes; he had sixteen of these instruments when he died.[47]

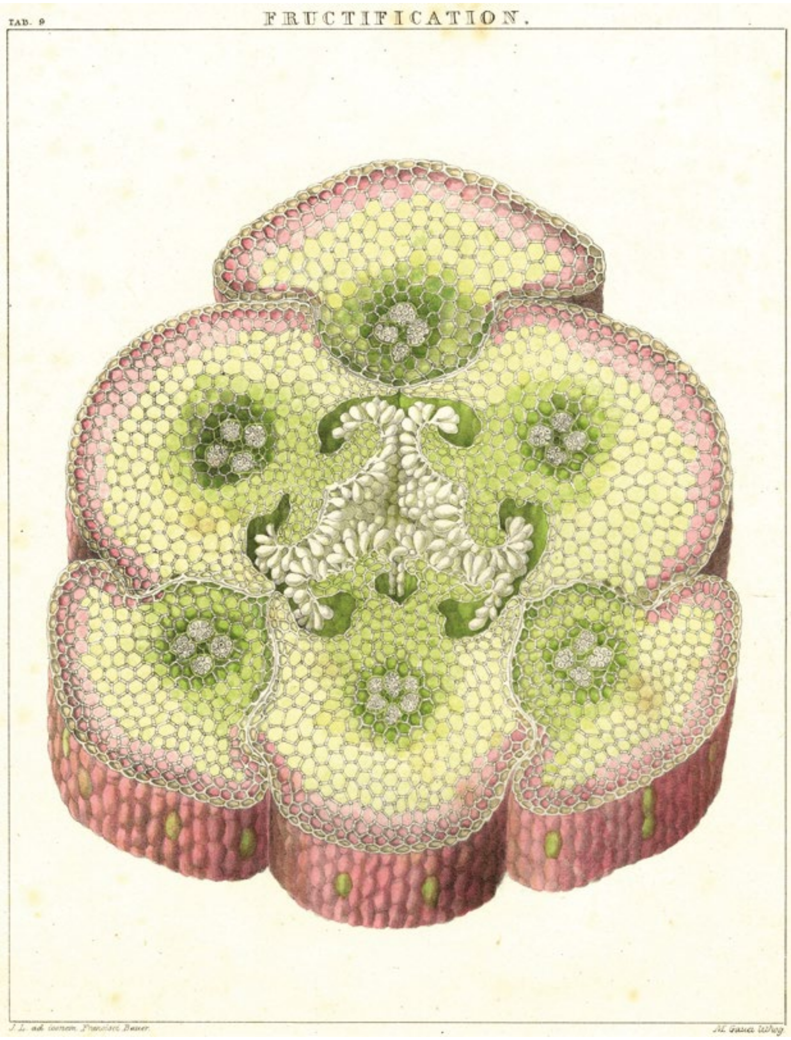
Carefully selected illustrations from Bauer's collection were finally published in collaboration with the young, ambitious British botanist John Lindley – also a devotee of orchids – in the part-work *Illustrations of Orchidaceous Plants* (1830–38). Lindley was a talented botanical illustrator in his own right, having illustrated his *Monographia rosarum* (1820) and *Collectanea botanica* (1821–6).[48] Within the narrow society of serious London-based naturalists, the Royal Society, the Horticultural Society and the Linnean Society provided opportunities for these two affable and gregarious men to meet. Moreover, the old man and his young colleague shared similar social backgrounds – distinct from those of their illustrious, wealthy patrons.

The world of orchids that Bauer depicted in watercolour under his microscope, and that Lindley published in lithographs, is extraordinary. However, the two men did not work as a team; rather, Lindley used illustrations that Bauer had made as early as 1791. The text associated with each plate is minimal, since Bauer's record of what he saw could speak for itself. Lindley was considerate of the older man's experience and aware that he was transforming Bauer's work: 'it is however hoped that the principal facts explained by the drawings have been faithfully represented, and that the defects of some of the plates as works of art will not be prejudicial to them as illustrations of science.'[49]

There are no second places in the history of ideas, which in science means having the idea, and producing and publishing the evidence for others to criticize.[50] Bauer had accumulated information about the microscopic

structure of orchids for nearly four decades, during a time when scientific knowledge about these plants was amassing rapidly. Moreover, he worked at the heart of the early nineteenth-century botanical establishment in Britain. He was a well-known and respected man, so visits made to him at Kew by British and European naturalists are likely to have produced mutual insights about the biology of orchids. However, he showed little interest in publishing what he discovered, remaining content to add to his accumulated knowledge and inform his visitors.

In contrast, Lindley, with passive-aggressive undertones, was keen to reassert priority for some of Bauer's microscopical orchid observations: 'Should the reader take an interest in such investigations [scientific priority]



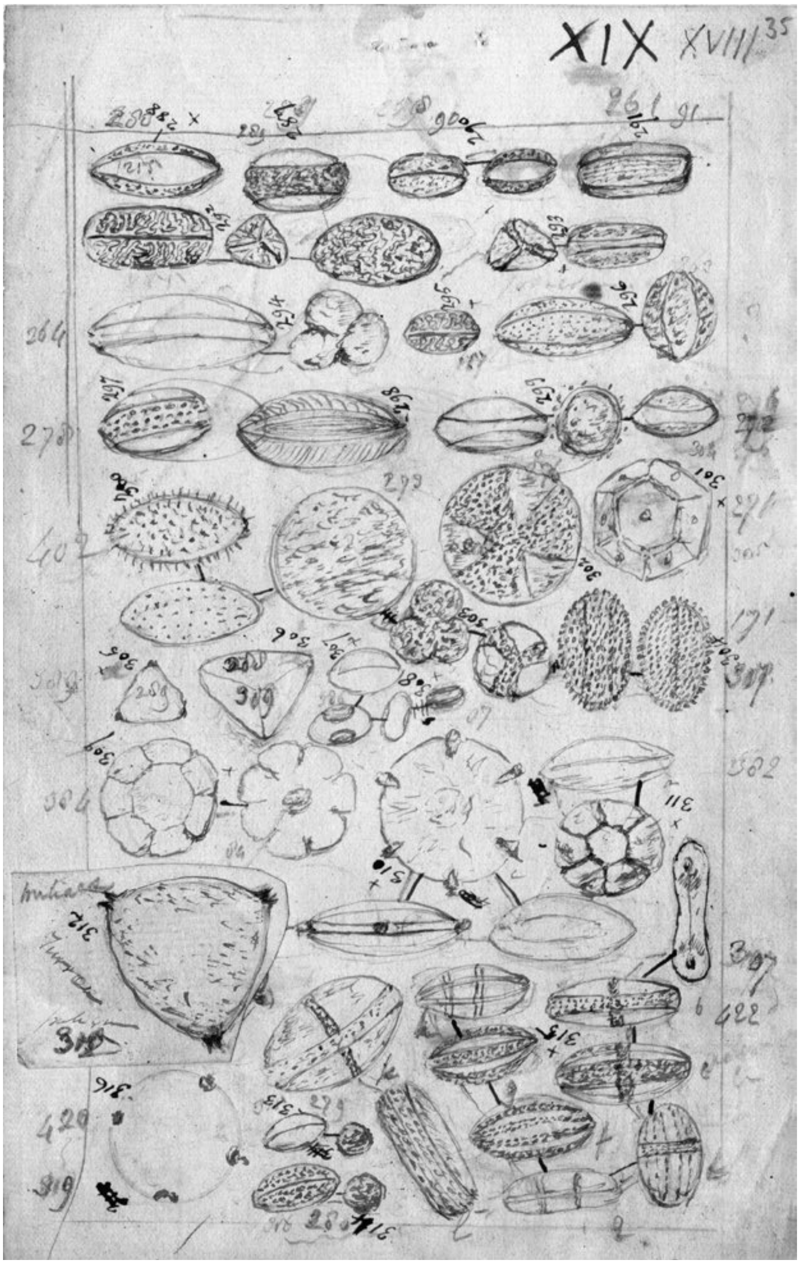
Three-dimensional reconstruction of a 60x magnification cross-section through the ovary of the Central American and Caribbean pine-pink orchid, from Franz Bauer and John Lindley's *Illustrations of Orchidaceous Plants* (1830–38). The original botanical illustration by Franz Bauer, made in 1801, was modified by Lindley before the plate was prepared for printing by lithographer Maxim Gauci.

I refer him to the dates of Mr Bauer's drawings, and by comparing them with the dates of other publications he can judge for himself to what amount of credit this most admirable and original observer is entitled.'[51] The target for Lindley's comments has been suggested as Robert Brown, the first Keeper of the Botanical Department of the British Museum.[52] Priority was a theme that Bauer reprised in his own right when a flurry of papers on the cause of ergot in grasses was published just before his death.[53]

Sex on a stick

Gradually, in eighteenth- and nineteenth-century Europe, the sexual functions of flowers revealed by scientists were incorporated into popular culture. Nehemiah Grew used sketchy copper engravings to depict the pollen ('globulets') of eleven species.[54] They ranged from that of the snapdragon, which were 'no bigger through a good *Microscope*, than the least *Cheese-Mite* to the naked Eye', through the '*Cubick*' grains of the pansy (*Viola*) to the large, spherical grains of mallow (*Malva*), 'beset round with little Thornes'.[55]

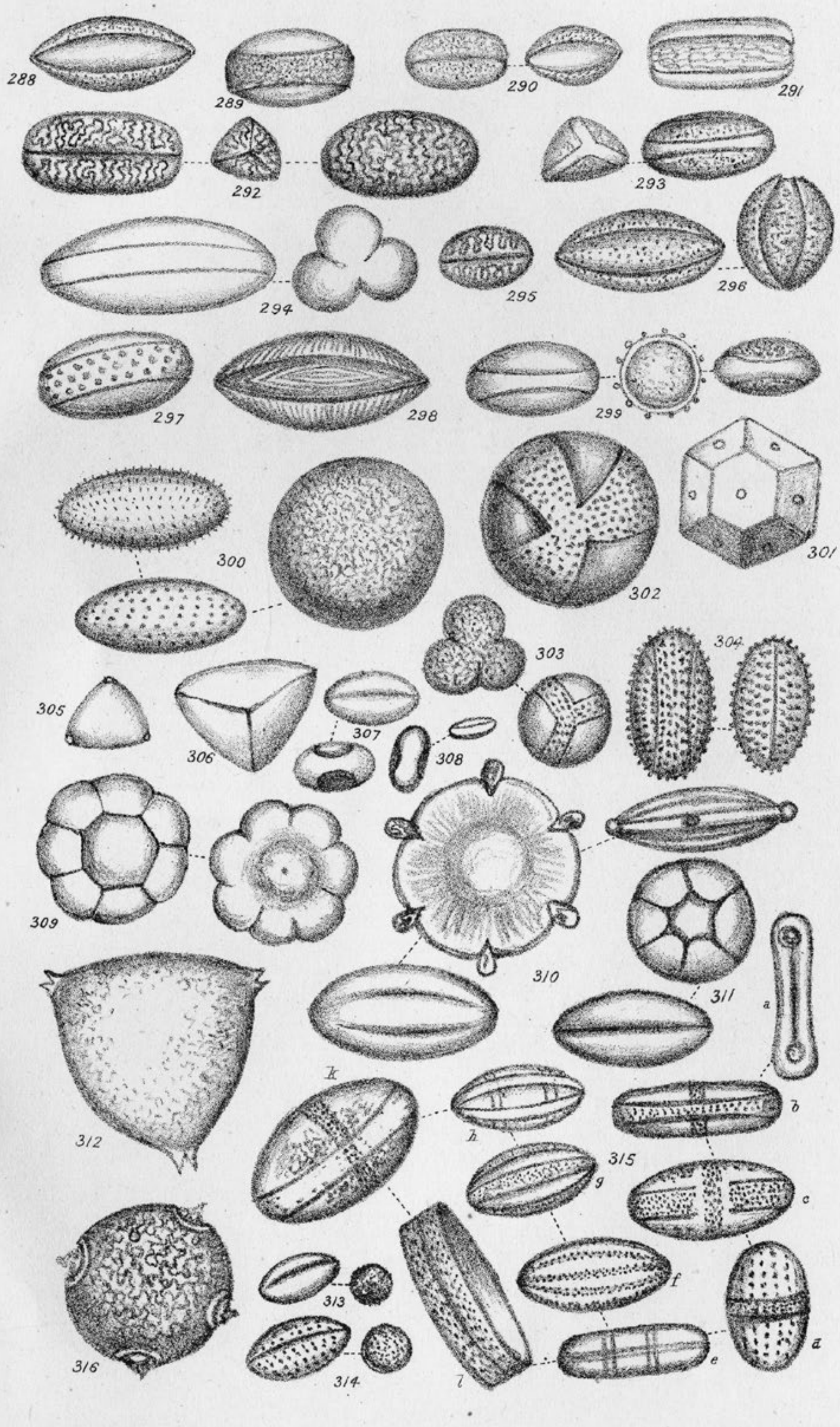
Pollen grains offered the nineteenth-century microscopist and botanical illustrator the opportunity to investigate easily prepared, visually attractive objects.[56] The German pharmacist Carl Julius Fritzsche's doctoral thesis on pollen was published in 1837 and illustrated with thirteen coloured lithographs of pollen grains.[57] In 1842 the English physician and microscopist Arthur Hill Hassall published a paper containing six plates, engraved by James De Carle Sowerby and based on 158 drawings made by Hassall, Utinia Nolcken and Amelia Hunter, on pollen as a tool for identifying flowering plants.[58] However, the editor of the journal apologized for the fact that it took a year to publish the paper, blaming the tardiness on 'the number of illustrations' that had to be made. By the time the Irish botanist Michael Pakenham Edgeworth produced *Pollen* (1877), 'illustrated with 438 figures' drawn by Edgeworth and lithographed by the French artist Philibert Charles Berjeau, the publication of highly illustrated botanical works was much more rapid than it had been three decades earlier.[59] Today the microscopical identification of pollen grains is routine in areas as diverse as air-quality assessment, forensics and the reconstruction of ancient habitats and climates – although images are usually presented as photographs.



Lithograph (opposite) by Philibert Charles Berjeau of magnified pollen grains from Michael Pakenham Edgeworth's *Pollen* (1877). Edgeworth made the original illustrations and laid out the pages (left) from which Berjeau worked.

During the first three decades of the nineteenth century, Franz Bauer drew pollen grains in order to record their diversity. In his drawings he also recorded mixtures of full and 'aborted' pollen released by the anthers of hybrids, and the structure of germinating pollen grains.[60] However, all these observations were recorded in his private notes, which were not published during his lifetime. Commenting on Bauer's illustrations of

M. P. Edgeworth. del. Pl. XIX.



C. Berjeau. Lith, Banks & Co., Edinr.

pollen, the palynologist Roger Philip Wodehouse asserted in 1935 that had the illustrator's work 'been published during his lifetime, the science of pollen morphology would now be considerably in advance of what it is to-day'.[61] However, decades after Wodehouse's analysis, one historian of science complimented Bauer on the 'beauty and scientific accuracy' of his illustrations with one hand but, with the other, dismissed them as of 'little scientific worth' and having 'made no lasting contribution'.[62] Bauer's images became footnotes in the history of cytology and plant reproductive biology, joining a thick file of botanical illustrations that made no scientific contribution because they were not published.[63]

Peloric mutation of common toadflax showing the whole plant, its root and details of the flower. Linnaeus's reaction to first seeing a specimen of the plant was apparently that it was '*Antirrhinum Linaria* [yellow toadflax], with the flowers, as he suspected, of some exotic, stuck on it'.[67] Hand-coloured copperplate engraving by an unknown artist and engraver, from William Curtis's *Flora Londinensis* (1777).

Herbal monstrosities

Linnaeus was contemptuous of men – the florists – who devoted their attention to such 'botanical aberrations' as fasciation (the abnormal fusion of parts), variegation (stripes or patches of a different colour), phyllody (where reproductive structures become leaves) and the proliferation of plant parts.[64] However, botanical monstrosities have been cosseted in gardens, conserved in cabinets of curiosities and even turned into myths through travellers' tales.[65] For a collection of physical objects or botanical illustrations to have true scientific value, it must be representative rather than populated only with the rare, the extreme and the exceptional; oddities are unrepresentative of variation in the natural world. In 1681, decades before Linnaeus, Grew was alive to the bias introduced by the monstrous as he catalogued the scientific collection of the Royal Society. The collection had, over a period of 25 years, become stegnotic with 'Things strange and rare', while those 'most known and common among us' were overlooked or put to one side.[66]

The attention of botanical illustrators and those who pay them is attracted by monstrous plants. For example, in the 1630s tulips were frequent inclusions in Dutch still-life paintings. We now know that these illustrations, produced at the height of 'tulipomania', are exquisite studies of random colour variants – a consequence of viral infection. In contrast, present-day 'Rembrandt' tulips, which simulate the appearance of those seventeenth-century infections, are stable colour variants. In nineteenth-century Britain, another 'mania' for within-species variants emerged: in

'Malus Citria Cornuta', Budda's hand, a citron mutation depicted in the Dutch botanist Abraham Munting's *Naauwkeurige beschrijving der aardgewassen* (Accurate Descriptions of the Earth's Crops, 1696). The unknown artist and copperplate engraver departed from seventeenth-century norms of botanical illustration by having the plant appear to levitate above a rural village landscape.

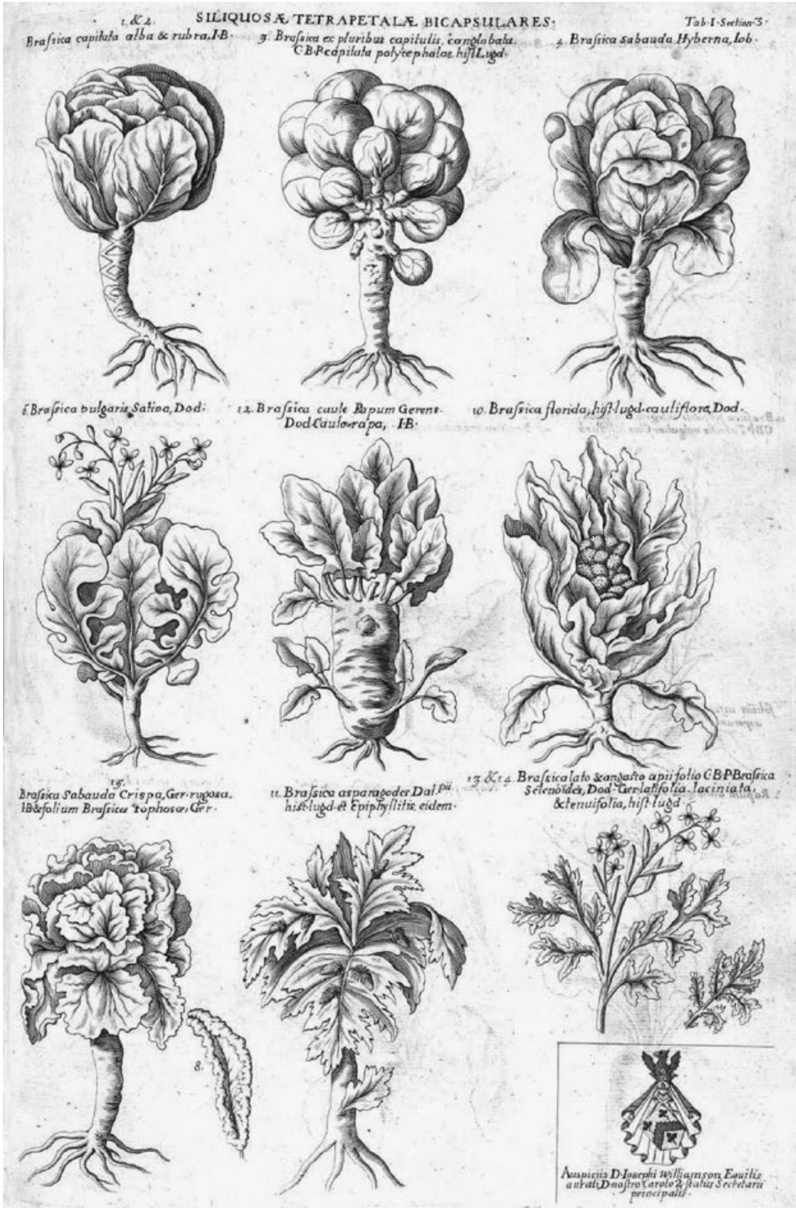

Fig. 3.
Fol. 8.
Malus Citria Cornuta.

ferns.[68] Collectors, such as the Irishman Patrick Bernard Kelly, could earn their living supplying natural fern mutations to Victorian gardeners. Among the elaborate illustrated volumes catering to this market was Thomas Moore's *The Ferns of Great Britain and Ireland* (1855), with its 51 plates of nature prints.[69]

Despite his dislike of botanical monstrosities, Linnaeus was fascinated by the flowers of a yellow toadflax with five lines of symmetry, rather than the customary single line.[70] He grew seeds from this unusual type and showed that more of the same were produced. He decided it was a new species, which he called *Peloria* (after 'pelorism', displaying radial symmetry), and that it was derived from the yellow toadflax. In Paris, Michel Adanson, who found that plants supplied by Linnaeus produced both normal and peloric flowers, concluded that *Peloria* was merely a monstrosity and not a new species.[71]

Frond form of a selection of specimens of common hart's-tongue fern collected across Britain: (1) wild type; (2) variety *polyschides*; (3) variety *marginatum*; (4) variety *crispum*; (5) forma *obtusidentatum*; (6, 7) forma *variabile*; (8) forma *irregulare*; (9) forma *lacinatum*; and (10) variety *laceratum*. Nature print made by Henry Bradbury and published in Thomas Moore's *The Ferns of Great Britain and Ireland* (1855; original hand coloured).

By the end of the nineteenth century, botanists 'medling with Mystick, Mythologies, or Hieroglyphick matters' as they attempted to name each slight variant within a species had become a botanical sideshow.[72] However, the amalgamation of the evolutionary ideas of Charles Darwin with the rediscovered ideas of Gregor Mendel in the first half of the twentieth century showed that nature's botanical monsters (mutations) reveal fundamental truths about the lives of plants. *Brassica oleracea*, the wild cabbage – which is grown as such familiar mutations as cabbage, kale, broccoli, kohlrabi, cauliflower and Brussels sprouts, unconsciously selected by generations of plant breeders – helps to answer questions underlying the genetic architecture of plants. Unknowingly, the florists and the original domesticators of crop plants were in effect plant breeders who have enabled us to discover how species survive and change outside the care of humans.



Cabbage forms, including headed cabbage, brussels, kohlrabi, cauliflower and kale, all of which have been selected by humans from coastal wild cabbage. Copperplate engraving by an unknown artist and engraver, from Robert Morison's *Plantarum historiae universalis oxoniensis* (1680). Each image in the plate was copied from woodcuts published in sixteenth-century and early seventeenth-century botanical books.

Microscopic moulds

Fungi, 'callosit[ies] of the earth', do not fit traditional views of nature's order.[73] Observing that they were transient, and apparently without means of reproduction, early modern naturalists asked fundamental questions about fungi that were little different from those posed by the ancient Greek philosopher Theophrastus.[74] Were fungi living or dead; if living, were they

animal, vegetable or something else? In 1552 Hieronymus Bock stated, 'fungi and truffles are not herbs, root, flowers or seeds, but merely superfluous moisture of earth, trees, rotten wood, and other rotting things. This is plain as all fungi and truffles, especially those used for eating, grow most commonly in thundery, wet weather.'[75] In the twelfth edition of *Systema Naturae* (1766–8), Linnaeus relegated them to the 'dustbin-group' he appropriately called *Chaos*, arranged under the *Vermes* ('worms'), as part of the animal kingdom, in his classification that split the entire natural world among separate vaults.[76]

Difficult to order because of the minuteness of their features, fungi have until recently also proved difficult to preserve permanently for comparative purposes using techniques familiar to taxonomists – those scientists who name and classify organisms. Fungi lose both colour and form when dried, and are readily attacked by insects and other fungi. Coloured illustrations have been at the heart of cataloguing fungal diversity, and providing the means to identify species, for centuries.[77] Moreover, the interpretation of illustrations has played an important part in developing the understanding of the fundamental roles of fungi in the processes that maintain life on Earth.

Fungi have traditionally been studied as plants, as Robert Hooke supposed when he included them among the objects presented in his *Micrographia* (1665). One copper-engraved plate shows 32-times magnification of the fungal disease *Phragmidium* as 'a Plant growing in the blighted or yellow specks of Damask-rose-leaves, Bramble-leaves, and some other kind of leaves', and the pinhead-like 'blue Mould' *Mucor*, sampled from a 'white spot of hairy mould' growing on a book cover.[78] However, Hooke could see no further: 'what these heads contain'd I could not perceive; whether they were knobs and flowers, or seed cases, I am not able to say.'[79] The Florentine botanist Pier Antonio Micheli looked more closely. In *Nova plantarum genera* (New Plant Genera, 1729), he observed that the heads were filled with dust (spores), which, given suitable conditions, germinated to produce more fungus.[80] Micheli showed that all the many fungi he examined produced spores.

Headway appeared to be made in bringing order to *Chaos* when, over a period of ten years, the German botanist Johann Hedwig wrote *Descriptio et adumbratio microscopico-analytica muscorum frondosorum* (Description

The clergyman and mycologist Miles Joseph Berkeley, one of the founders of the science of plant pathology, painted *Pleurotus fimbriatus* (top) from East Bergholt in Suffolk, eastern England, in January 1852. In 1879 his daughter, the illustrator Ruth Ellen Berkeley, painted *P. ruthae* (bottom), from Coed Coch in Denbighshire, Wales, and which her father named in her honour in the same year with his thanks for finding 'many of the novelties of the season'.[81] These paintings were among hundreds that the Berkeleys contributed to the 1,198 chromolithographs used to illustrate Mordecai Cubitt Cooke's *Illustrations of British Fungi (Hymenomycetes)* (1881–91).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M.J.B.
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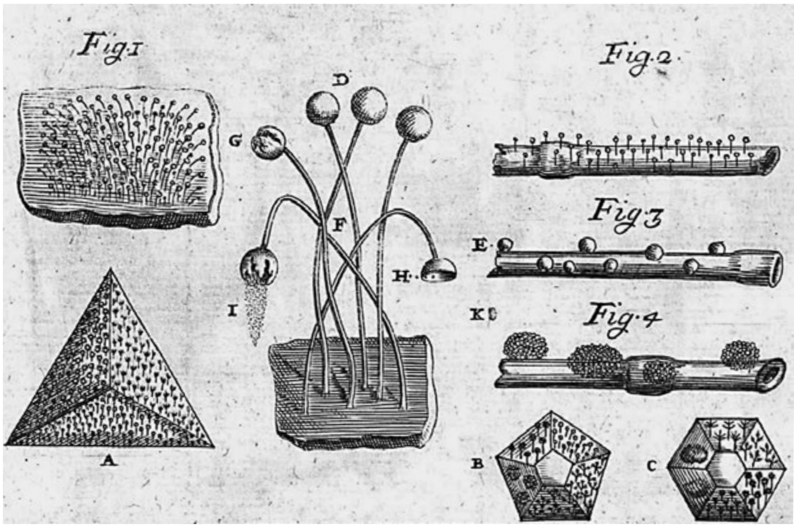
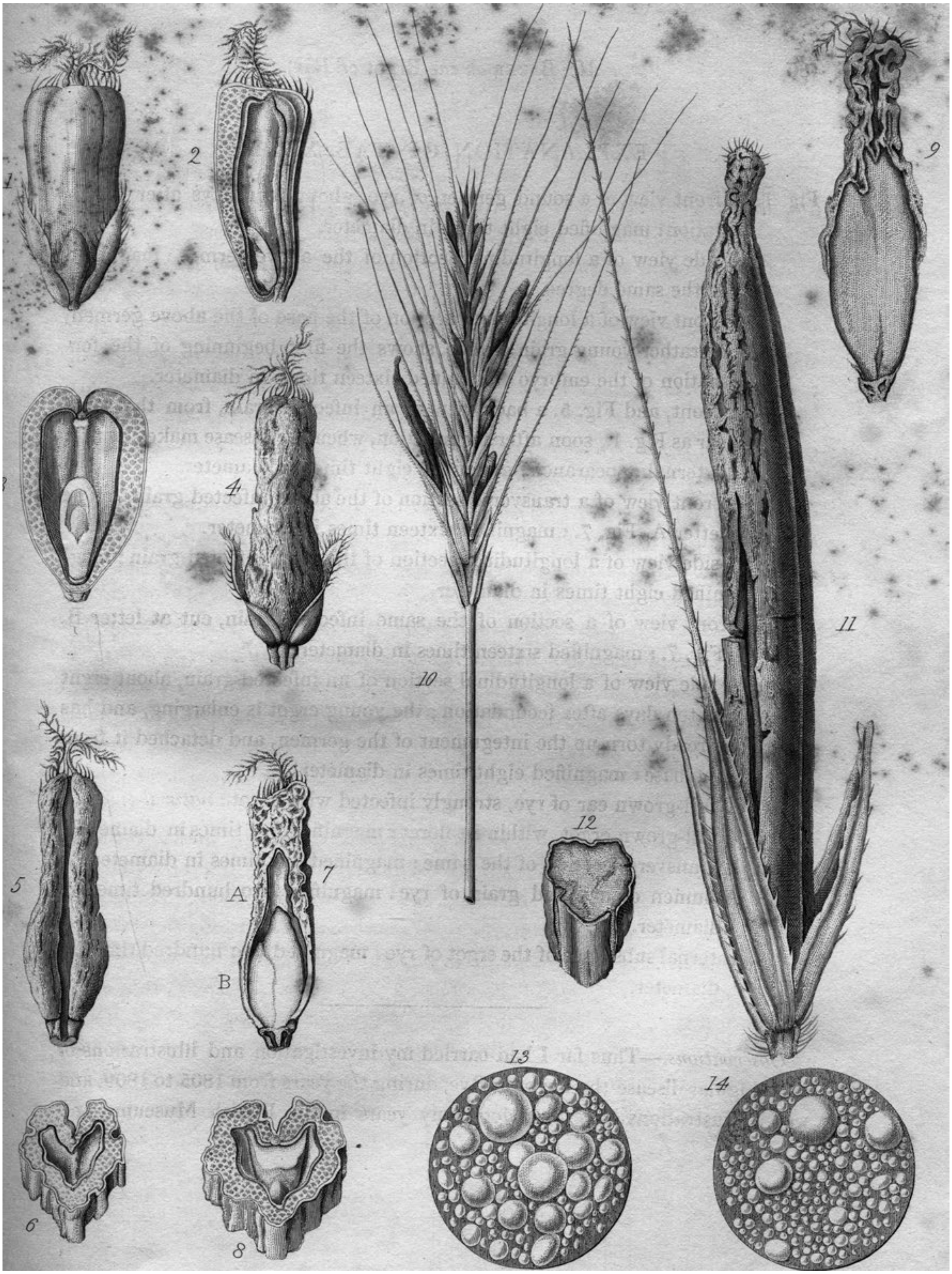


Pier Antonio Micheli's cluster of the microscopic fungus *Mucor* (Fig. 1) with the reproductive pinheads breaking to liberate spores (I), together with a representation of the fungus' life cycle (A). Other microfungi and their life cycles (B, C) are represented on the other half of the plate from *Nova plantarum genera* (1729). The copperplate engraving was sponsored by the English prelate and botanist Robert Uvedale, the man who introduced the sweet pea into British gardens.

and Microscopic-Analytical Account of Leafy Mosses, 1787–97). He was primarily concerned with the microscopic features of mosses. However, among the 160 hand-coloured copperplate etchings published in Leipzig, there is a collection of thin sections through macroscopic fungi and lichens that show that in some fungi the spores are arranged in flask-shaped sacs, each containing eight spores. The Scottish botanist Robert Kaye Greville appears to have assumed that all macroscopic fungi have their spores inside sacs. When he published his detailed fungal drawings – many showing magnified enlargements – in 360 metal-etched, hand-coloured plates in a monthly part-work entitled *Scottish Cryptogamic Flora* (1822–8), he showed bagged spores in sections of cap-fungi for at least nineteen species.[82] In the 1830s British and continental European botanists confirmed that the gills of cap-fungi (including the familiar cultivated mushroom) do not have sacs, but rather are covered with club-shaped cells, each of which has four stalked spores.[83]

Mushrooms, toadstools and moulds are obvious when they are reproducing, but for most of their lives they are hidden from sight. During the nineteenth century the concealed lives of fungi began to draw the attention of naturalists, while technology for seeing improved. New observations and new ideas needed new descriptive language to replace that which could be misinterpreted or was inadequate to communicate complex, hard-won microscopical observations. High-quality illustrations came to the fore as the means to record and communicate observations. However, if

Franz Bauer's illustrations of stages in the development of ergot fungus sclerotia, the cause of St Anthony's fire, on rye. Bauer carefully asserts that the original drawing was made in 1806, more than three decades before it was converted into an engraved steel plate by George Jarman. Images range from natural size, as in the case of the infected rye ear (centre), to 200x magnification for the interior of the sclerotium (lower right).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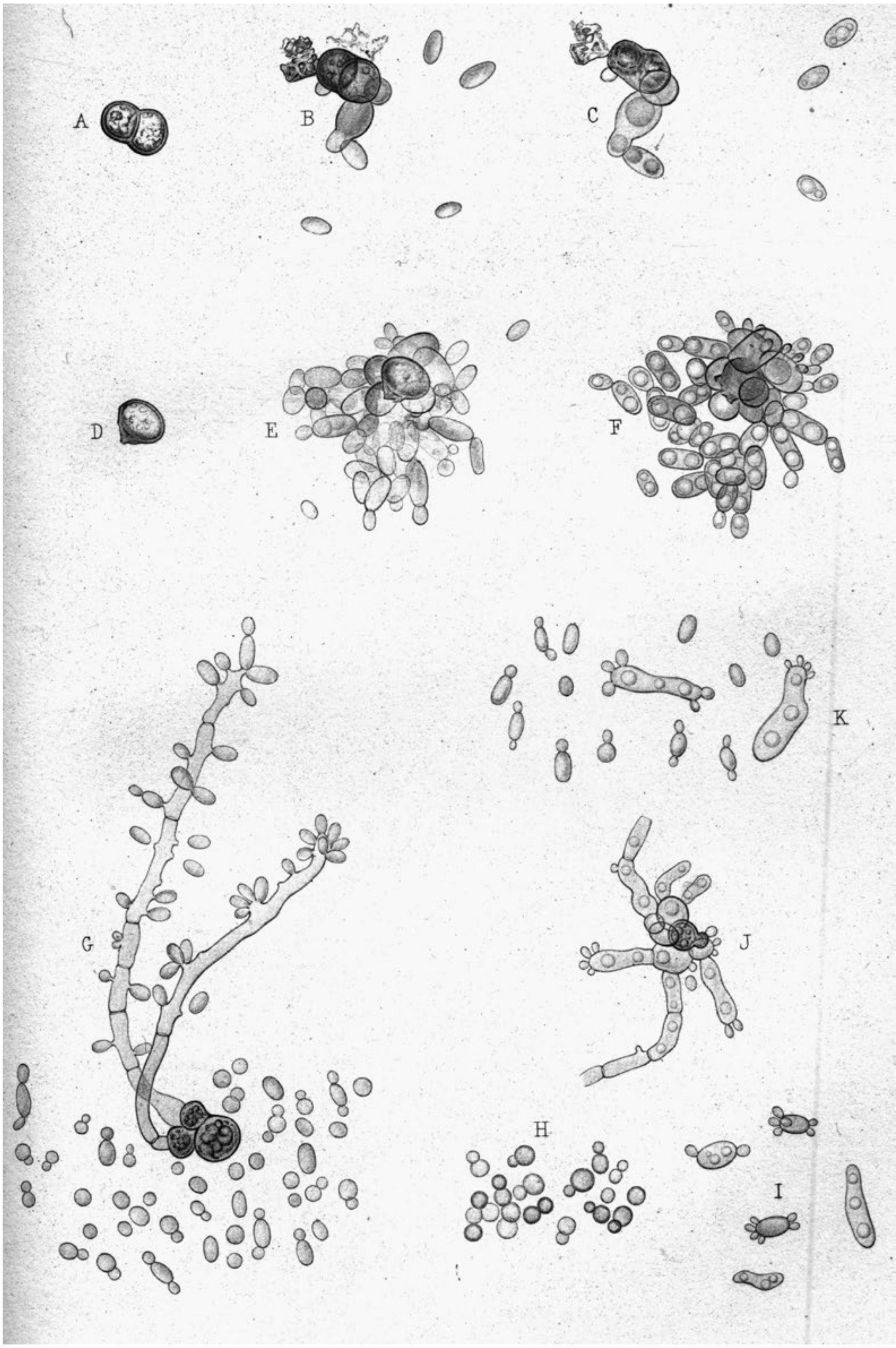
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'Exemples de germinations de cellules de la poussière extérieure des grappes de raisin' (Examples of cell germination from grape bloom), a plate of fungi from Louis Pasteur's *Études sur la bière* (1876). Deyrolle's drawings of yeasts, at 500x magnification, cultured from the surface of grapes, were etched by an artist called Picart.

observational or experimental evidence based on such investigations were to be accepted by sceptical researchers, in such competitive fields as the study of plant diseases and fermentation, people had to trust the veracity of the illustration, and the illustrator's relationship with both naturalist and printer.

The French microbiologist Louis Pasteur's study of beer and its 'diseases', *Études sur la bière* (Beer Studies, 1876), has 85 in-text illustrations.[84] Most of these are crude sketches of fungal cells under the microscope, redrawn by unknown artists from laboratory notes. In addition, twelve high-quality black-and-white metal etchings of magnified cells are interleaved in the text. These were probably based on Pasteur's own laboratory sketches and redrawn for publication by Peter Lackerbauer and Deyrolle, while the plates were etched by two artists identified as 'E. Hellé' and 'Picart'. These artists and craftsmen were professional scientific illustrators or plate makers, essential elements in the business of publishing. Deyrolle was probably a member of the family behind the eponymous Parisian natural-history and taxidermy business.

Today we know that fungi are not plants, but rather another kingdom of life. Despite their importance, and the fact that they are far more diverse and important than we ever imagined, fungi – especially those that are visible only under the microscope – remain the interest of a narrow group of specialized naturalists and professional biologists.[85]

UNTIL THE MID-TWENTIETH century, the magnifying glass and the microscope were the tools that enabled botanists to explore the inside of plants and fungi, and the fundamental building blocks that contribute to the appearance of these organisms. Magnification, the key to the smaller of Roos's rooms, forces an illustrator to become more than an eye, to become an explicit interpreter and editor. They must filter the real from the artefact if they are to depict their subject with accuracy and truth, but without becoming carried away by wonder. Magnification also reveals the limits of traditional approaches to botanical illustration, making light, and – today – pixels, the preferred media for depicting the microscopic world.

seven

HABIT AND HABITAT

> Bonpland assured me that he would go stark mad if the excitement didn't stop soon.
>
> ALEXANDER VON HUMBOLDT, *Personal Narrative* (1814–29)[1]

No matter their experience, field naturalists are never deserted by wonder at plant diversity, especially in the tropics, or fail to be overwhelmed by it. By 1825 the 44-year-old William Burchell, a veteran field naturalist-artist, had spent ten years collecting in southern Africa and St Helena before describing the first Brazilian plants he saw in their native habitats as 'of remarkable forms, combined in the most picturesque manner, tempt[ing] one to turn often from Natural History to Painting'.[2] Seven years later Charles Darwin, as Robert FitzRoy's companion on the voyage of HMS *Beagle* (1831–6), had a similar reaction to the Brazilian forests:

> Delight itself, however, is a weak term to express the feelings of a naturalist who, for the first time, has wandered by himself in a Brazilian forest. The elegance of the grasses, the novelty of the parasitical plants, the beauty of the flowers, the glossy green of the foliage, but above all the general luxuriance of the vegetation, filled me with admiration . . . To a person fond of natural history, such a day as this brings with it a deeper pleasure than he can ever hope to experience again.[3]

Burchell and Darwin responded to combinations of plants growing in their native habitats, rather than to individual plants displayed or

Brazilian Atlantic forest, near Rio de Janeiro, dominated by communities of epiphytic plants, such as orchids, cactuses, aroids, begonias, ferns, bromeliads, lianas and palms. Lithograph from Carl Friedrich Philipp von Martius's *Flora Brasiliensis* (1906).

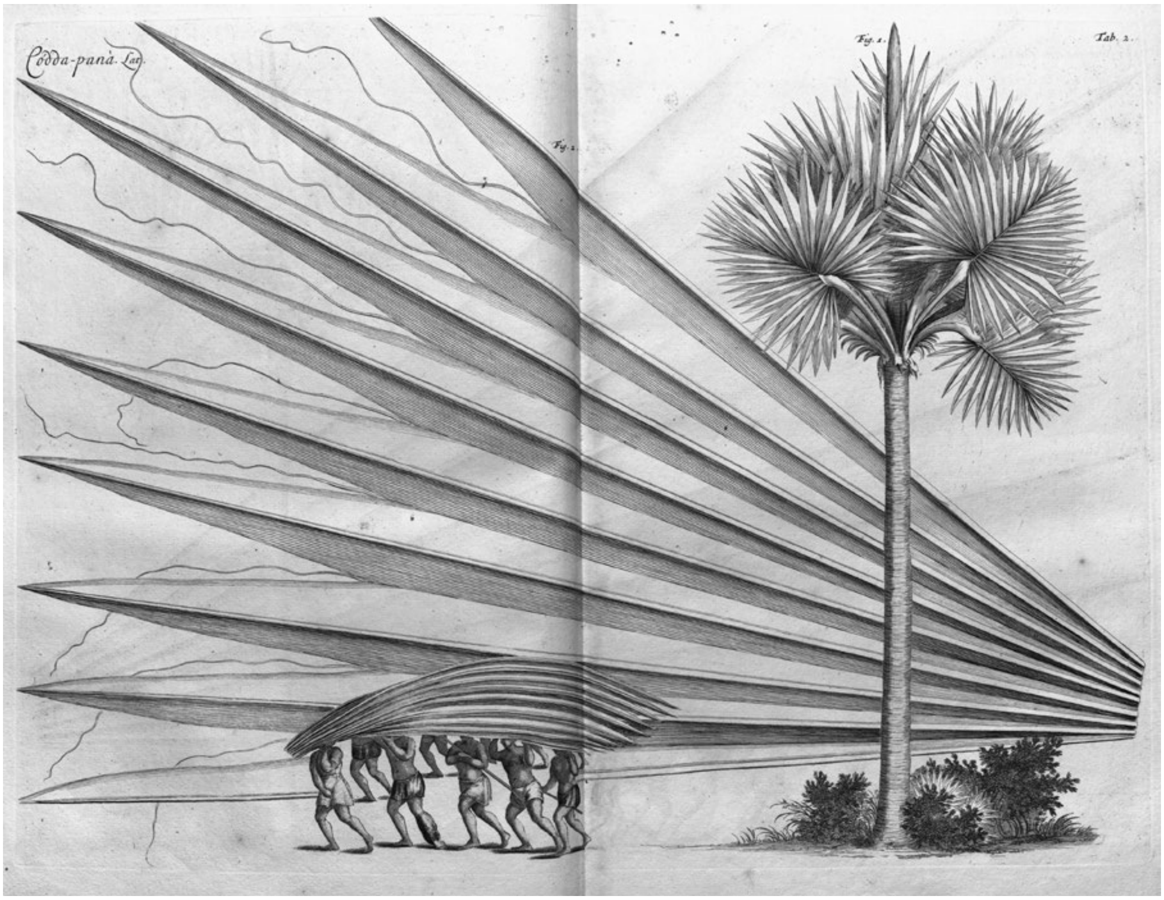
artificially combined in gardens, museums or illustrations. For naturalists to investigate the diversity of plants and the pattern of their distribution, and to understand how they grow, thrive and reproduce, accurate knowledge of plant form, habitat and interaction is essential.

During his Latin American expedition (1799–1804), the Prussian naturalist Alexander von Humboldt, in addition to collecting and illustrating plants, made sketches of landscapes and the plants within them, and measured the physical characteristics of the environment using the best instruments available to him.[4] His research changed the way naturalists, such as Darwin, approached the exploration of the natural world. It became comparative, so that measurements and quantification were as important as the qualitative recording of appearance. Moreover, a field of science emerged – plant biogeography – in which plant distribution is investigated with reference to the physical characteristics of the environment.[5]

Before the advent of photography, most naturalists interested in the environments in which plants lived had to reply on word portraits from travellers, fragments of objects in museums, and images created by landscape and topographic artists. When Joseph Hooker reported on his explorations of the Himalayas, he emphasized his objective skills:

> the landscapes, &c. have been prepared chiefly from my own drawings, and will, I hope, be found to be tolerably faithful representations of the scenes. I have always endeavoured to overcome that tendency to exaggerate heights, and increase the angle of slopes, which is I believe the besetting sin, not of amateurs only, but of our most accomplished artists . . . My drawings will be considered tame compared with most mountain landscapes, though the subjects comprise some of the grandest scenes in nature.[6]

The danger persisted, that voids in knowledge would be filled by travellers' tales, often embellished with each retelling, and imagined landscapes created in response to limited data, the desire to please or the lure of the exotic. This chapter focuses on the role of botanical illustrators in documenting the habits of plants in natural landscapes, and myths about them, from the poles to the equator and from sea level to beyond the treeline. In



Habit of the talipot palm, 'Codda-panà', as it begins to flower, together with a portion of a leaf blade. Metal engraving from Hendrik Adriaan van Rheede tot Drakenstein's *Hortus malabaricus* (1682), by an unknown engraver, based on the work of an unknown illustrator.

the process, these illustrators added to our knowledge of plant life, and began to document how humans have modified the natural environments in which they live.

Reality among the myths

The early sixteenth-century map of Brazil made by the Portuguese cartographer Lopo Homem shows indigenous people harvesting logs of *Paubrasilia echinata*, source of the red dye brasil.[7] The French explorer Jean de Léry's successful *Histoire d'un voyage fait en la terre du Brésil autrement dite Amerique* (History of a Voyage to the Land of Brazil, Also Called America, 1578), with its graphic woodcuts, appealed to the imagination of Europeans in the seventeenth century, and continues to do so.[8] Popular accounts had many exotic countries populated by cannibals, and filled with fabulous

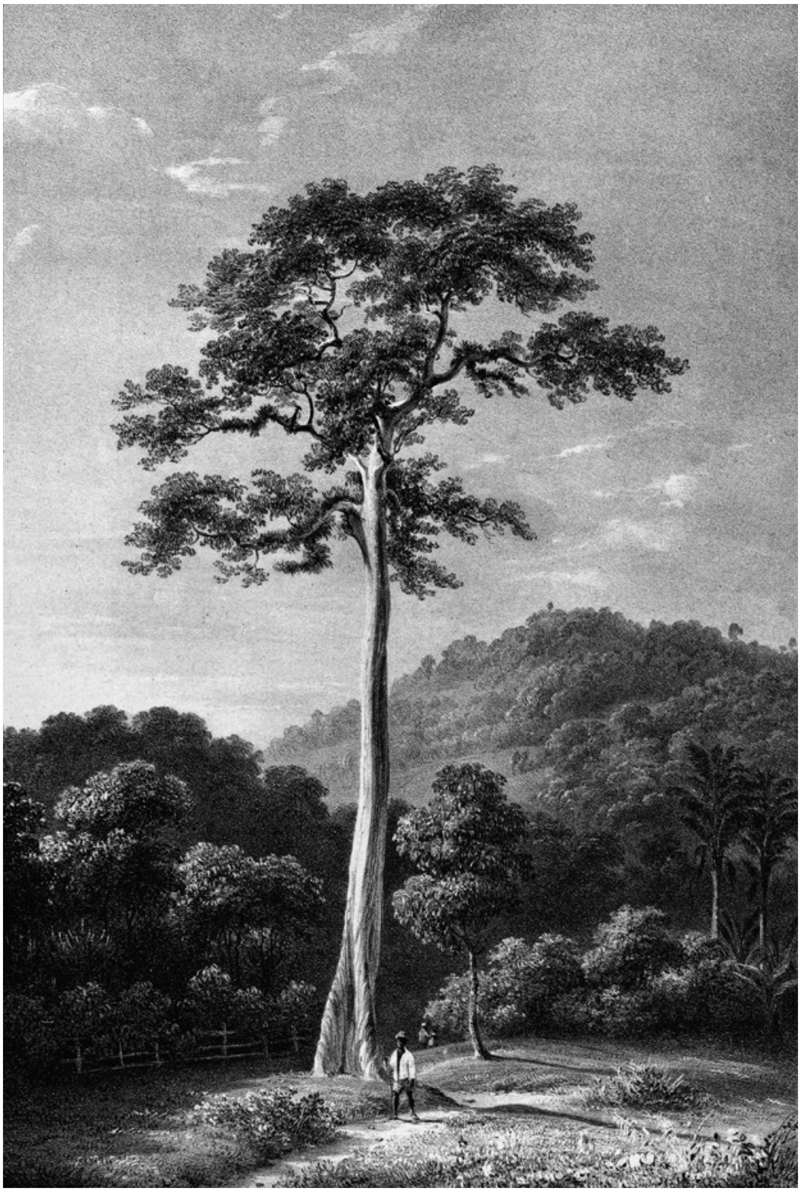
animals roaming landscapes replete with plants to cure all human ills, sprouting from earth rich in gems and precious metals.[9] In the 1830s, during his five-year botanical exploration of the interior of Brazil, George Gardner winnowed grains of truth from the chaff of myth, as he collected plants and investigated claims about Brazilian natural history made by chroniclers 'more famed for their wit than their veracity'.[10]

Botanical myths were in circulation long before the discovery of the Americas. 'A strange wonder of Nature and prince of all marine things', the double coconut or coco de mer was, until 1768, known only from curious woody structures, with the appearance of a pair of human buttocks, sometimes found as flotsam in the Indian Ocean.[11] The 'blind seer of Ambon', the German-Dutch botanist Georg Eberhard Rumphius, in his posthumously published six-volume *Herbarium amboinense* (1741–50), included an engraving of the coco de mer, together with a precis of various late seventeenth-century fabulous tales about it.[12] These tales supposed that double coconuts were produced by trees that grew under the sea, or that the trees were home to birds capable of savaging elephants and rhinoceroses. Unsurprisingly, such notoriety fuelled the European demand for coco de mer, especially when rumours of its supposedly wondrous medicinal properties emerged.

The first scientific description of the coco de mer palm was made by the French naturalist Philibert Commerson, who accompanied the explorer Louis-Antoine de Bougainville on a circumnavigation of the Earth (1766–9). Commerson was famously assisted by the naturalist Jeanne Baret, who was disguised as a man.[13] Baret became the first woman to circumnavigate the world, but Commerson died before his work was published, and his association with coco de mer was overlooked until the beginning of the following century. The first illustration of the living coco de mer palm was made by the naturalist Pierre Sonnerat on the island of Praslin in the Seychelles. With the discovery that the palm was endemic to the Seychelles, some of the romantic gloss associated with the coco de mer disappeared and it became relegated to a mere botanical curiosity.

Palms, 'stamped by Nature with such elegance and majesty of form', presented northern visitors to the tropics with a plant life form that was unusual and hence attracted attention.[14] In tropical southern and south-eastern Asia, Europeans discovered that a fan palm – the talipot palm

An isolated, buttress-rooted upas tree (up to 40 metres/130 ft high), the survivor of forest clearance, rather than a botanical mass killer. The Belgian illustrator Paul Lauters's lithograph, based on an illustration by the Belgian artist-naturalist Auguste Antoine Joseph Payen, was published in Karl Ludwig von Blume's *Rumphia* (1835).



– was 'employed by natives to write on with their pointed steel bodkins, and are also split to tie the rafters of their houses together, for they are found to be strong and durable'.[15] This is a giant among palms, reaching 25 metres (82 ft) in height, with circular leaves 5 metres (16½ ft) in diameter and leaf stalks almost as long. It flowers only once in its lifetime, when it is between 30 and 80 years old, producing a branched flower head up to 8 metres (26 ft) long, containing millions of flowers. In the multi-volume *Hortus*

malabaricus (The Garden of Malabar, 1678–93), published under the auspices of the Dutch colonial administrator and naturalist Hendrik Adriaan van Rheede tot Drakenstein, a remarkable series of twelve engravings conveys the immense size of the palm and illustrates the details of the changes it goes through during its life cycle.[16]

Another Asian plant swaddled with travellers' tales is the upas tree, a Javanese plant that was thought so toxic that it would kill all living things found within a 24-kilometre (15-mile) radius of it. However, the rulers of Java would pardon condemned prisoners sent to harvest the tree's valuable poison – if they survived. Such tales gained common currency among Western naturalists in the 1780s following supposed eyewitness testimony by an Indonesia-based Dutch surgeon called Foersch.[17] The physician and thinker Erasmus Darwin even wove the upas tree into his prose poem 'The Loves of the Plants' (1791): 'Fierce in dread silence on the blasted heath/ Fell UPAS sits, the Hydra-Tree of death.'[18] The tree is now known as *Antiaris toxicaria*, a relative of the mulberry, and is distributed through the Old World tropics and subtropics from West Africa to Polynesia.

Making the fabulous, ordinary

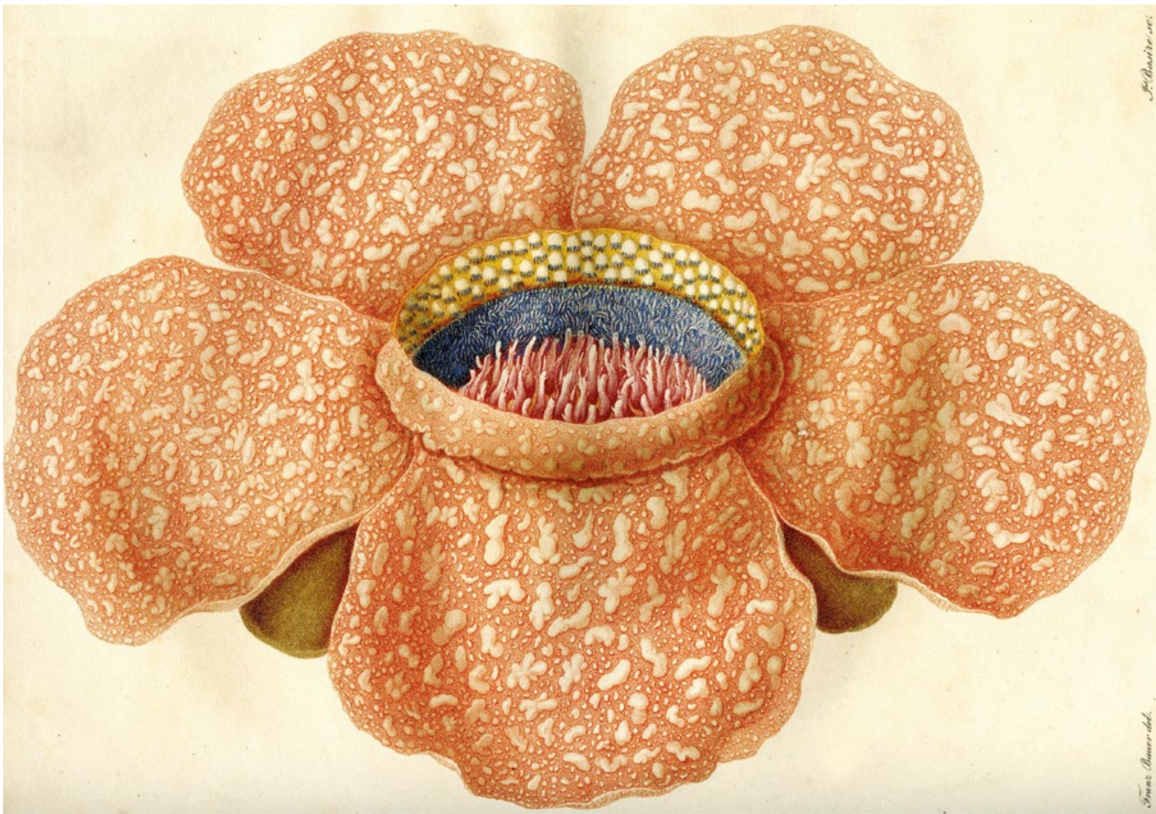
Field-based illustrators make the first drafts of our knowledge of plants' habits and habitats. In times past, these illustrators' audiences, which were often far away from where the plants grew, may have considered such places inhabited by too 'few intelligent persons'.[19] Words, partial knowledge and a willingness to believe contributed to such mythologies as those of the coco de mer and the upas tree. In early nineteenth-century Europe, two plants provoked astonishment: a Sumatran 'gigantic Flower' and an Angolan 'excessively ugly' plant.[20] Illustrations – made by artists in the company of the appropriate witnesses – prevented such surprising botanical discoveries from becoming too fabulous.

The scientific name of the corpse flower, *Rafflesia arnoldii*, commemorates two British men who brought this Sumatran parasite to the attention of European botanists: Thomas Stamford Raffles, lieutenant-governor of Bencoolen (today Bengkulu City, Indonesia), and the botanist Joseph Arnold.[21] Unfortunately, we do not know the identity of the 'Malay servant' who ran to Arnold 'with wonder in his eyes, and said, "Come

with me, Sir, come! A flower, very large. Beautiful, wonderful!'"[22] When Arnold saw this flower, a few months before he died, his first impulse was to collect it and then surround himself with credible witnesses:

> To tell you the truth, had I been alone, and had there been no witnesses, I should I think have been fearful of mentioning the dimensions of this flower, so much does it exceed every flower I have ever seen or heard of; but I had Sir Stamford Raffles and Lady Raffles with me, and a Mr Palsgrave, a respectable man resident at Manna . . . [who] are able to testify as to the truth.[23]

Arnold made a coloured drawing of the fleshy flower before preserving 'it in spirits . . . but from the neglect of the persons to whom it was intrusted, the petals were destroyed by insects, the only part that retained its form being the pistil which was put in spirits along with two large buds of the same flower, which I found attached to the same root: each of these is



A single male flower of the Sumatran *Rafflesia arnoldii*, the world's largest flower, which is parasitic on the woody vine genus *Tetrastigma*. This illustration of a plant that rarely flowers has been widely copied since its publication in 1822. James Basire's hand-coloured metal engraving based on an illustration by Franz Bauer, who based his illustration on an original field watercolour by Joseph Arnold.

Whole, uprooted individual and habit of male plants of the southwestern African gymnosperm *Welwitschia mirabilis*. Hand-coloured lithograph by Walter Hood Fitch, based on an illustration by the Portuguese soldier Fernando da Costa Leal for Friedrich Welwitsch (above) and a field sketch by Thomas Baines. The parallel pencil lines added to the lower image apparently delimit an area for reproduction as a teaching poster in the department of botany at the University of Oxford in the late nineteenth century.

about as large as two fists.'[24] The drawing, and the preserved materials, were returned to Joseph Banks at Kew; they were used by Franz Bauer to produce illustrations that were converted to one coloured and seven black-and-white engravings by the English engraver James Basire for a publication by Robert Brown.[25]

In 1860 the Austrian botanist Friedrich Welwitsch reported that while travelling through Angola, between Moçâmedes in the southwest and the mouth of the Kunene River – 'the most beautiful and the most magnificent scenery that the tropics of South Africa can offer' – he discovered 'the most wonderful plant ever brought to this country [Britain] – and the very ugliest'.[26] He remarked that it was 'so overwhelming that he could do nothing but kneel down on the burning sand and gaze at it, half in fear lest a touch should prove it a figment of the imagination'.[27] In May 1861 two experienced explorers of Africa, the English artist Thomas Baines and the South African photographer James Chapman, discovered the same – then nameless – plant in 'desolate gorges' of the Swakop River, Namibia.[28] Baines's 'attention was drawn to a singular plant of immense size. Whether it were new to science I could not tell; a vagrant artist can neither afford nor carry the necessary books of reference. I saw that it was new to me, and determined to secure the best sketch and specimen I could before I rejoined the waggons.'[29]

The Swedish explorer and hunter Karl Johan Andersson forwarded Baines's specimens and illustrations of the plant to William Jackson Hooker in 'a box containing some admirable coloured drawings illustrating the vegetation of that country, together with the cones and a sketch of a plant'. Hooker claimed: 'I never saw it before, nor has more than one person ever done so – that person is Dr Welwitsch.'[30] Like the *Rafflesia*, Welwitsch's and Baines's plant was known to indigenous people, since both plants had common names, but nineteenth-century attitudes considered such people inappropriate as either witnesses or holders of knowledge about the plants with which they lived.[31]

Baines's materials became part of the formal description of *Welwitschia mirabilis*, which Hooker's son Joseph named in honour of Welwitsch's 'indefatigable and successful botanical labours in tropical Africa'.[32] Joseph complained, however, that Baines's 'box was not accompanied by any letter, nor the specimens and drawings by descriptions . . . and were packed without being dried . . . and not arriving at Kew until late in the following autumn, they were then all in a very decayed state'.[33] With limited information, Hooker tried to balance apparently conflicting data when drawing up his description: 'Mr Baines's sketch of the plant . . . somewhat differs from Dr Welwitsch's description . . . Mr Baines's sketch is, however, more artistic than scientific.'[34]

In the early twentieth century the South African botanist Henry Harold Welch Pearson published a photograph of a welwitschia with extensively tattered leaves, creating the appearance that there were more than two leaves, which is one of the species' characteristics. He also implicitly criticized Baines, who 'might be forgiven for representing a plant not very different from this', together with Walter Fitch's colouring of a lithograph in Hooker's work: 'the angles of the cone are not sufficiently dark, and the colour of the remainder is too bright.'[35]

By the end of the nineteenth century welwitschia was the 'subject of a remarkable number of notices in horticultural, botanical and even popular literature'.[36] In 1862, however, Andersson had written to William Jackson Hooker:

> I would have sent a specimen years ago, had I not been under the impression that you had already specimens of it; for I assisted a

Imagined habit for *Rafflesia arnoldii*, probably based on Franz Bauer's illustrations of a bud and opened flower from Robert Brown's account of the species in *Transactions of the Linnean Society of London* (1822), and published in Louis Figuier's *The Vegetable World* (1869). Wood engraving by Charles Laplante, based on an illustration by Auguste Faguet.

> Mr Wollaston once to excavate a couple, which I thought he purposed presenting to the Kew Gardens. I know that the specimens were received at the Botanical Garden at Cape Town; for I saw them there only the other day, pitched away among some rubbish. No one seemed to take the slightest notice of them, which rather surprised me, since the plant cannot well escape even the dullest eye, it is so singular.[37]

Welwitschia mirabilis and *Rafflesia arnoldii* remain species of singular biological interest, although only the former has been cultivated in botanical collections outside the species' native range.[38] *Welwitschia mirabilis* plants studding the landscapes of the Namib desert, and the large, foetid flowers of *Rafflesia arnoldii*, have made both species tourist attractions in their native ranges.

Botanical illustrators depicted these plants with rigour, careful to record what they saw without interpreting it, and conscientiously avoiding the fabulous. However, such illustrations may be copied by others to create powerful visual fables, accidentally or otherwise. For example, the prolific French botanical illustrator Auguste Faguet used Bauer's illustrations of the flower and buds of *Rafflesia arnoldii* to construct a menacing habitat for the plant, at the same time increasing the size of the flowers dramatically – making them almost human-sized.

In plain sight

Descriptions of plants that amazed explorers, such as *Rafflesia* and *Welwitschia*, which might provoke disbelief in European capitals, 'would be impossible to render intelligible without copious drawings'.[39] Arnold's and Baines's field sketches and drawings were first published in technical journals, accompanying detailed scientific descriptions of new botanical discoveries. In other cases, illustrations of similarly dramatic plants might be published in limited-edition subscription volumes where the focus was on those 'subjects as combine scientific interest with remarkable beauty in form or colour, or some other qualification that would render them eminently worthy of cultivation'.[40]

Sikkim rhubarb is a herbaceous giant, 'the most striking of many fine alpine plants of Sikkim . . . upwards of a yard high, and form conical towers of the most delicate, straw-coloured shining, semi-transparent, concave, imbricating bracts, the upper of which have pink edges'.[41] Its natural distribution extends through the alpine zone of the Himalayas from Afghanistan in the west through Nepal, Bhutan and Tibet to Myanmar in the east. When Joseph Hooker, who explored the Himalayas and India between 1847 and 1851, first spotted the species from 'a distance of fully a mile, dotting the black cliffs of the Lachen valley [Sikkim] at 14,000 feet [about 4,300 metres] elevation, in inaccessible situations', he was 'quite at a loss to conceive what it could be' until he examined it more closely.[42] Biologically, the curious form of this rhubarb has been attributed to the bracts that surround the flowers, acting rather like a greenhouse to protect the plant from extreme temperatures and ultraviolet light.[43]

The best-known illustration of the plant, which was copied by publications across Europe in the nineteenth century, was published in Hooker's *Illustrations of Himalayan Plants* (1855).[44] For this subscription volume, Hooker selected 24 illustrations from a collection of nearly 1,000 prepared for John Ferguson Cathcart of the Bengal Civil Service in India, to reproduce as folio-sized chromolithographs:[45] 'Mr Fitch . . . has redrawn all the Plates, availing himself of my preserved specimens and analyses, and, by his own unrivalled skill in seizing the natural characters of plants, has corrected the stiffness and want of botanical knowledge displayed by the native artists who executed most of the originals.'[46] The accompanying drawing

W. Fitch del. et lith.

Vincent Brooks Imp.

RHEUM NOBILE, H.f. & T.

of the plant's habit was 'taken from a sketch of the whole plant, of natural size, which I [Hooker] took, and which covers two folio sheets of paper (that is, four times the area of the Plate)'.[47]

Besides wishing to 'ensure the association of his [Cathcart's] name with the progress of Indian Botany', Hooker wrote that *Illustrations of Himalayan Plants* was an opportunity to promote botany in general and to encourage 'members of that branch of the service to which he [Cathcart] was so long attached, – a branch of which all the members have the means, and all, at one period or other of their career, the time, to devote to the advancement of some department of science, whether as amateurs or as students'.[49] A continual supply of data from plants in the field, and funding, was essential as Hooker and his colleagues built the science of botany into a professional discipline in nineteenth-century Britain.[50] These data could be supplied by explorers – mostly young men – collecting plants while they were doing other things; botanical illustrations were a means of tantalizing them with the sort of novelty they might be lucky enough to discover.

In North America, groves of giant redwood trees, which are restricted to parts of the western Sierra Nevada, California, were known to Native Americans long before Europeans first encountered them in the mid-nineteenth century.[51] When Marianne North painted redwoods in 1875, she commented that 'all the world now knows their dimensions, so I need not repeat them; but only those who have seen them know their rich red plush bark and the light green eclipse of feathery foliage above, and the giant trunks which swell enormously at the base, having no branches up to a third of their whole height.'[52]

Twenty-two years earlier, in 1853, William Lobb, a plant collector for Veitch's nurseries of Exeter and Chelsea, had seen the trees and recognized their immense horticultural potential and financial value to his employer.[53] By the end of that year John Lindley had formally described the tree as *Wellingtonia gigantea*, with assertions that there was 'no room for doubt that Wellingtonia is an entirely new coniferous form', and that it was 'impossible to overestimate the value to Great Britain of such a tree'.[54] The French botanist Charles Naudin was sceptical that it was new to science, however: 'we fear that the alleged virginity of Mr Lobb's tree is, despite appearances, only a usurped glory.'[55] Despite the dispute, Veitch soon capitalized on the material Lobb collected, and the cachet of 'this wonderful tree', to charge

Hand-coloured lithograph of Sikkim rhubarb made by Walter Hood Fitch for Joseph Dalton Hooker's *Illustrations of Himalayan Plants* (1855). Of this illustration, Hooker states, 'The accompanying drawing is taken from a sketch of the whole plant, of natural size, which I took, and which covers two folio sheets of paper (that is, four times the area of the Plate).'[48]

Isolated tree of the North American giant redwood, based on an original illustration by Joseph Lapham and copied by Louis-Constantin Stroobant for inclusion in the horticultural journal *Flore des serres et des jardins de l'Europe*, as a gatefold chromolithograph, in 1853.

two guineas (about £165 in 2022) per sapling. Moreover, the entrepreneur charged *7s 6d* (about £30 in 2022) for a lithographed plate of the tree, based on an original illustration by the North American artist Joseph Lapham.[56] Lapham, who owned a grove of giant redwoods that is now part of the Calaveras Big Trees State Park, established a hotel to serve the needs of the stream of visitors who eventually flocked to see these natural wonders.

A lone tree stands in the middle distance of Lapham's illustration, isolated in a parkland landscape. Just visible at its base are people on foot and

horseback. In the foreground, framing the work, is a group of Native Americans and a Western couple gazing at the scene. Lapham's image, which gives an impression of the size of the giant redwood, was soon copied by European publications. For example, in 1853 the Belgian horticulturalist Louis Benoît van Houtte in his illustrated horticultural journal *Flore des serres et des jardins de l'Europe* used a gatefold chromolithograph copy by the artist Louis-Constantin Stroobant, which repeated the diameter and height (31 feet/about 9.5 metres and 290 feet/about 88 metres, respectively) of the more than 3,000-year-old tree, but made it more symmetrical than in the original.[57] Copies appeared in 1854 as a hand-coloured lithograph by Fitch in *Curtis's Botanical Magazine*, and a wood engraving in the newly founded *Belgique horticole*.[58] The illustration was still being copied more than a decade later.[59]

In 1877 the editor of *The Garden* resorted to a different approach to give the impression of the size of *Wellingtonia*. He published a wood engraving captioned 'Dance on a "Big Tree" Stump', where five couples are shown dancing to a musical trio, with four spectators, and the comment:

> among the various ways of giving an idea of the vast size of the Pines in some parts of the Sierra Range in California few are more suggestive than the engraving this week, which represents an actual occurrence after the cutting down of one of the biggest of the sound trees, some of which, it will be remembered, are nearly or quite 40 ft [about 12 metres] in diameter.[60]

In a forest, it is difficult to see, and hence illustrate, individual trees. Lapham solved the problem by stripping the tree from the surrounding forest, just as gardeners plant specimen trees. The tree has an opportunity to grow to its full potential and form, but is isolated from the habitat in which it naturally grows. Those who copied Lapham's image appeared uninterested in habitat, modifying foregrounds and backgrounds according to their tastes and purposes. When North visited the Calaveras Grove, she stated that one of her 'first subjects was the great ghost of a tree which had had a third of its bark stripped off and set up in the Crystal Palace; the scaffolds were still hanging to its bleached sides, and it looked very odd between the living trunks of red plush on either side.'[61] Unlike Lapham's

sentinel, North's completed paintings place giant redwoods within their habitat, adding to the impression of such groves as natural cathedrals.[62] Although she witnessed the harvesting of redwood groves, and the surrounding forest, her comments reflect a particular concern for the aesthetic effect of tree loss in landscapes, rather than the wider range of biological concerns that might be expressed today: 'it broke one's heart to think of man, the civilizer, wasting treasures in a few years to which savages and animals had done no harm for centuries.'[63]

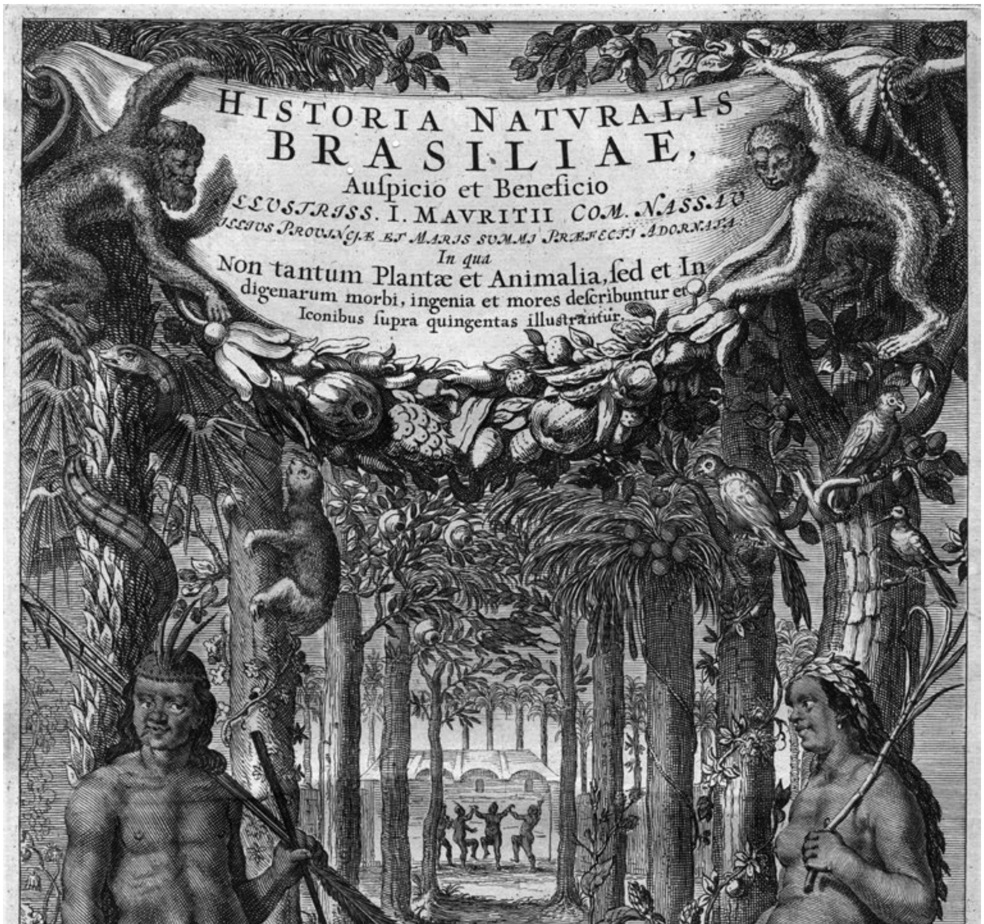
Pictures and words

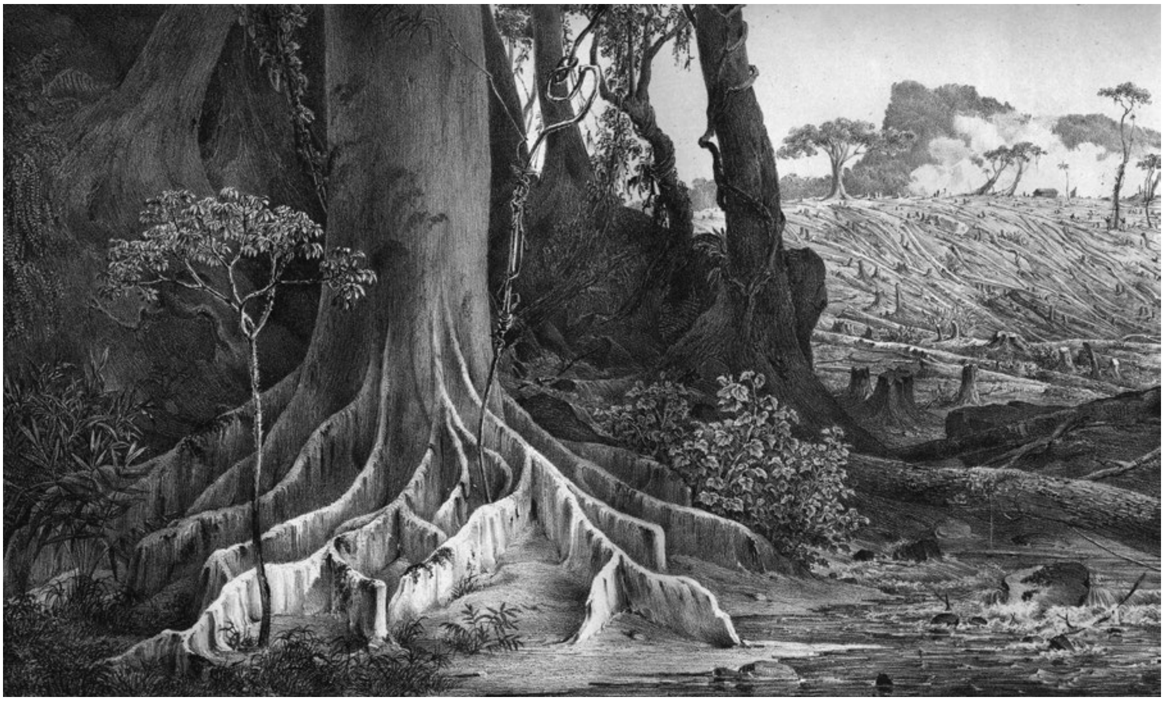
With hindsight, one of the first representations of plants within a naturalistic ecological context is Albrecht Dürer's watercolour *Das große Rasenstück* (The Great Piece of Turf, 1503), a piece of European turf in which such plants as cock's-foot, smooth meadow-grass, dandelion, greater plantain and yarrow are shown competing for space. Dürer's work is remarkable not only for the subject, but for its ability to force the viewer to examine a familiar object in detail. Before the nineteenth century, few European naturalists bothered to record habitats on their doorsteps in such detail, while landscape artists added plants as symbols and conventions to focus the viewers' eye and create mood, rather than record specific details of associations among species.[64]

Between 1637 and 1644, the Dutch artist Frans Janszoon Post was charged by the governor of Dutch Brazil with recording the colony's landscapes. Post, who worked from field sketches, has the accolade of being the first European artist to make landscape paintings in the Americas. He completed about 140 paintings, mostly after returning to Holland, and his work created a market, shaping European concepts of Brazilian landscapes until the early nineteenth century. However, his landscapes, and the lives of the people who inhabit many of them, are highly romanticized. Cactuses and palms, evidently based on the same sketches, are copied across paintings in stylized arrangements, sometimes giving the impression of idyllic European landscapes decorated with tropical elements.[65]

The Dutch physician Willem Piso and the German astronomer Georg Markgraf investigated tropical medicine, natural history and cartography across Dutch Brazil as Post undertook his work. Piso published their joint

A cultivated Brazilian sylvan landscape populated with plants, people and animals forming the engraved title page of Willem Piso and Georg Markgraf's *Historia naturalis brasiliae* (1648). Although the scene is imagined, many of the plants are delineated with sufficient detail to make them identifiable. The artist of this landscape is likely to have composed it from traveller's tales, fragmentary sketches and specimens.


HISTORIA NATVRALIS
BRASILIAE,
Auſpicio et Beneficio
ILLVSTRISS. I. MAVRITII COM. NASSAV
ILLIVS PROVINCIÆ ET MARIS SVMMI PRÆFECTI ADORNATA.
In qua
Non tantum Plantæ et Animalia, ſed et In-
digenarum morbi, ingenia et mores deſcribuntur et
Iconibus ſupra quingentas illuſtrantur.
LVGDVN. BATAVORVM,
Apud Franciſcum Hackium
et
AMSTELODAMI,
Apud Lud. Elzevirium. 1648.



Dry forest of the *caatinga* in northeastern Brazil. The barrel-shaped barricuda in the centre of the image is being viewed by two Europeans as five men, presumably slaves or servants, tend the pack animals. The cactuses and bromeliads in the undergrowth present a habitat that would have been alien to most European naturalists. Lithograph from Carl von Martius's *Flora Brasiliensis* (1906).

investigations as the *Historia naturalis brasiliae* (Natural History of the Brazils, 1648), which was heavily illustrated with woodcuts of animals and plants. The elaborate, engraved title page gives the impression of abundance in a tropical paradise. Two indigenous people head an avenue of tropical trees that focus the eye on to a village scene with people dancing. In the foreground, a wreathed Neptune slouches behind a shell, his left elbow on a turtle and his right hand on a vase that overflows with marine bounty. An anteater laps from a clam shell, a sloth climbs a tree, and a snake is coiled around the palm behind the indigenous man. There is a tree in fruit, related to the Brazil nut, which bears so-called monkey pots that are traditionally used to make traps for simians. Two anthropoid-looking primates hold a swag replete with tropical fruit, including figs and cashews. Behind Neptune is a row of plants that includes pineapple and the Brazilian staple manioc. A passion flower, with flowers and fruit, twines around the trunk of a tree, while the woman holds a bunch of cashews. The artist accurately illustrated parts of plants, but the whole is a work of imagination that records nothing of the habitats in which these plants naturally grow. It is a confection – an inky paper garden – in the manner of Christopher Switzer's title-page woodcut for John Parkinson's *Paradisi in sole* (1629).

When the Bavarian naturalists Johann Baptist von Spix and Carl Friedrich Philipp von Martius arrived in Rio de Janeiro, Brazil, in 1817, they were familiar with Piso and Markgraf's work. They could hardly wait to explore the surrounding forests, to place in context the plants and animals they knew from descriptions, illustrations and dead specimens in natural-history collections:

Interface between virgin and cleared Brazilian Atlantic forest on a river margin, near Rio de Janeiro in the early nineteenth century. The forms of tree roots and the lianas twining up the trunks are shown together with a sense of contact between the margin and the interior of the forest. The form of a tree too large to fell in the cleared area is shown, together with the slaves forced to remove the trees and live among the debris. Lithograph from Carl von Martius's *Flora Brasiliensis* (1906).

> Scarcely were we beyond the streets and the noise of the town [Rio], when we stopped, as if enchanted, in the midst of a strange and luxuriant vegetation . . . Surrounded by lofty airy cassias, broad-leaved, white-stemmed cecropias, thick-crowned myrtles, large-flowered bignonias, climbing tufts of the mellifluous paullinias, far-spreading tendrils of the passion-flower, and of the richly flowering hatched coronilla, above which rise the waving summits of Macaubu palms, we fancied ourselves transported into the gardens of the Hesperides . . . we at length reached the terrace of the eminence along which the spring water for the city is

> conducted. A delightful prospect over the bay, the verdant islands floating in it, the harbour with its crowd of masts and various flags, and the city stretched out at the foot of the most pleasant hills, the houses and steeples dazzling in the sun, was spread before our eyes. We dwelt long on the magical view of a great European city, rising here amidst the profusion of tropical vegetation.[66]

Spix and Martius created visceral, textual accounts of plants set in their natural habitats. In his later works Martius, working with artists influenced by the work of Humboldt, created realistic images of Brazilian landscapes. Moreover, the changes being wrought on species-rich landscapes in the nineteenth century were beginning to be recorded. By the late twentieth century the work of the British botanical artist Margaret Mee, who specialized in painting plants *in situ* in the forests of Amazonian Brazil, was drawing global attention to the destruction of these forests.[67]

CAPTURING NATURAL HABITATS or habits is a challenge for artists because of the multifarious ways in which they work. Few artists have the luxury of travelling and spending long periods studying their subjects in their native areas. Today, photographs of habitats around the world, and our impact on them, have become clichés that almost immunize us against awe and even concern. However, those images cannot prepare a traveller unfamiliar with such areas for that first encounter or the surprise of finding familiar garden plants growing wild. The sight, sound, touch, taste and smell of these areas are a revelation. Imagine how much more this must have been the case for naturalists and artists whose expectations were largely based on written and verbal accounts, and printed illustrations of variable quality. However, as Humboldt emphasized, if we are to understand the places where plants grow, and hence the biology of the plants themselves, observations must give way to detailed measurements and eventually to experimentation so that we can test our ideas.

eight

OBSERVE AND TEST

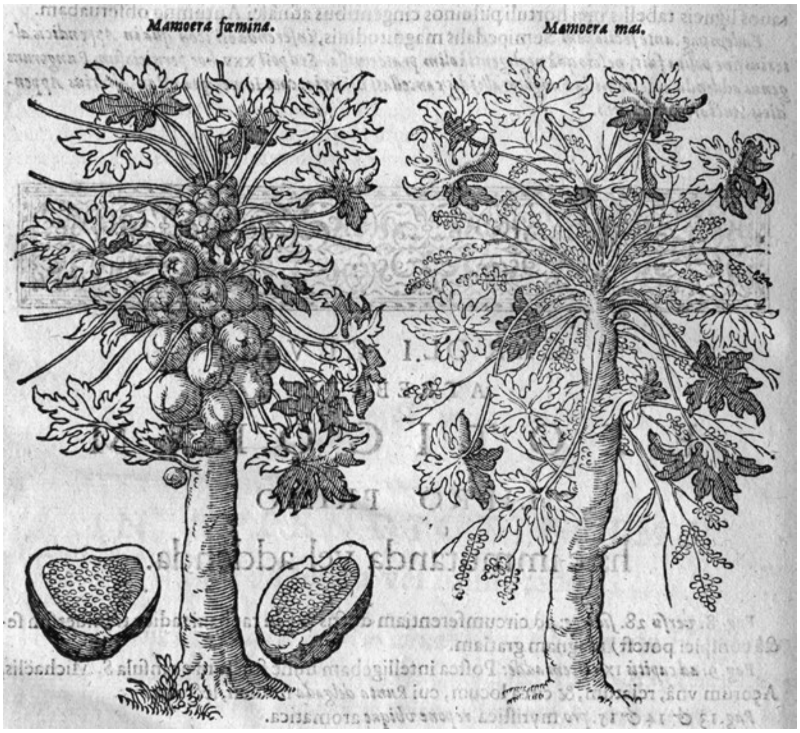
> I consider there might be a great many Data in Nature, which have escaped Observation; for if we employ a close Enquiry after the relative Properties of her Agency, and can divest ourselves of Bigotry and Prejudices, many improveable Hints are given, and to an unbiassed Enquirer, Truth shines by its own Light.
>
> JOHN TENNENT, *Physical Disquisitions* (1745)[1]

Recording the diversity of plants, giving them names and ordering them into classifications helps us to produce catalogues of life: starting points for investigating plants scientifically. However, to understand how plants evolve and go about their lives, and to test our ideas about how they function, we must experiment.

From the fifteenth century onwards new discoveries about the natural world challenged ancient authority. Some people met such challenges by aligning evidence to fit the existing orthodoxy. Others, such as Francis Bacon, believed that natural philosophers must be methodical, sceptical and willing to abandon such authority. He maintained that the investigation of empirical observations required reasoning from specific observations to arrive at probable, general hypotheses.[2]

Experimentation was central to the 'new philosophy' of Bacon and those who founded the Royal Society in 1660.[3] The supporters of established ideas naturally felt threatened.[4] For example, the English churchman Robert South preached at Westminster Abbey in 1667 that

> it cannot but be matter of just indignation to all knowing and good men, to see a company of lewd, shallow-brained



Seventeenth-century woodcut of the male (right) and female (left) plants of the American tropical fruit tree papaya. The illustrator of Charles de l'Écluse's *Curae posteriores* (The Latter Works, 1611), unfamiliar with the tree in the wild, made the tree's trunk too squat, but correctly assigned sex.

> huffs, making atheism and contempt of religion, the sole badge and character of wit, gallantry, and true discretion . . . censuring the wisdom of all antiquity, scoffing at all piety, and, as it were, new modelling the whole world.[5]

By the mid-twentieth century objective testing of hypothesis-driven science had crystallized in the concept of 'falsifiability': that is, a theory is accepted until hypotheses arising from it are rejected through an interactive process of observation, hypothesis, experimentation, evaluation and retesting.[6] Data gathered by botanical illustrators, through their accurate observations, facilitate the generation and testing of scientific hypotheses. However, observers must not be beguiled by the glamour of botanical illustrations. As we have seen, for example with Dampier's potato (Chapter One), inaccurate observations by an illustrator may lead a hopeful observer into a botanical cul-de-sac.

Instructional sex

For centuries, botanical illustrators, artists and botanists focused on representing floral form without making associations with biological function. Discounting known exceptions, such as the date palm, the accepted belief was that plants did not produce seed through sexual reproduction (the movement of pollen between individual plants), even though the clues are obvious with hindsight.[7] For example, in early seventeenth-century Britain, features of the fruit tree papaya were known only indirectly:

> trees . . . are of the same kinde, and differ only in sex; for the one of them, to wit, the male is barren, and only carries floures, without any fruit; but the female onely fruit, and that without floure: yet they say they are so louing, and of such a nature, that if they be set far asunder, and the female haue not a male neere her, shee becomes barren and beares no fruit.'[8]

Moreover, 'this fruit contains many kernels [seeds] of the bignes of a smal pease, blacke and shining, of no use that he [John Van Ufele] could learne, but which were cast away as unnecessary.'[9] The information is drawn from an account by Charles de l'Écluse, which was illustrated with woodcuts; the need to have male and female trees close together for the production of fruit is emphasized, but there is no indication of the nature of the relationship. Surprisingly for two men – Gerard and l'Écluse – who knew about practical horticulture, seed production was dismissed.

In 1694 Rudolph Jacob Camerarius, professor of natural philosophy at the University of Tübingen, Germany – the institution that had employed Leonard Fuchs in the sixteenth century – published experimental evidence in *De sexu plantarum epistola* (On the Sex of Plants), which countered assertions that sexual reproduction was exceptional in flowering plants.[10] In England at about the same time, Nehemiah Grew and Thomas Millington proposed that pollen was male in function. Furthermore, in the early eighteenth century ideas of plant sexuality championed by the French botanist Sébastien Vaillant would profoundly influence the work of Linnaeus and his Sexual Classification System.[11] As the century progressed, botanists

and illustrators focused on flower form and diversity as they fitted species into Linnaeus's changing classification system.

Despite people having observed insects around flowers for millennia, these creatures' possible role in the function of flowers remained of only marginal interest – even as the evidence mounted.[12] In the mid-eighteenth century the Scotsman Arthur Dobbs, governor of North Carolina in the American colonies, emphasized that bees collected nectar and pollinated plants: 'if the Facts are so, and my Observations true, I think that Providence has appointed the Bee to be very instrumental in promoting the Increase of Vegetables.'[13] Joseph Gottlieb Kölreuter, meanwhile, professor of natural history at the University of Karlsruhe, investigated experimental crosses within and among plant species.[14] The nineteenth-century German plant hybridizer Carl Friedrich von Gärtner summarized attitudes to Kölreuter's work: 'hybridization in its scientific significance was so little thought of, and at the most regarded merely as a proof of the sexuality of plants, that the many important suggestions and actual data which this diligent and exact observer recorded . . . have found but little acceptance.'[15]

One person took up Kölreuter's work: the German naturalist and classicist Christian Konrad Sprengel. When he published *Das entdeckte Geheimnis der Natur im Bau und in der Befruchtung der Blumen* (The Secret of Nature in the Form and Fertilization of Flowers Discovered) in 1793, Sprengel included 25 black-and-white, line-engraved plates of his own illustrations, containing 1,117 drawings of 461 species. Each packed plate is filled with magnified images of whole flowers, detailed dissections and in some cases insects. Within each plate, images are arranged to maximize the use of the available space, rather than paying attention to placing similar flowers together. The result is that these aesthetically curious, data-packed plates are difficult to use for comparative purposes.

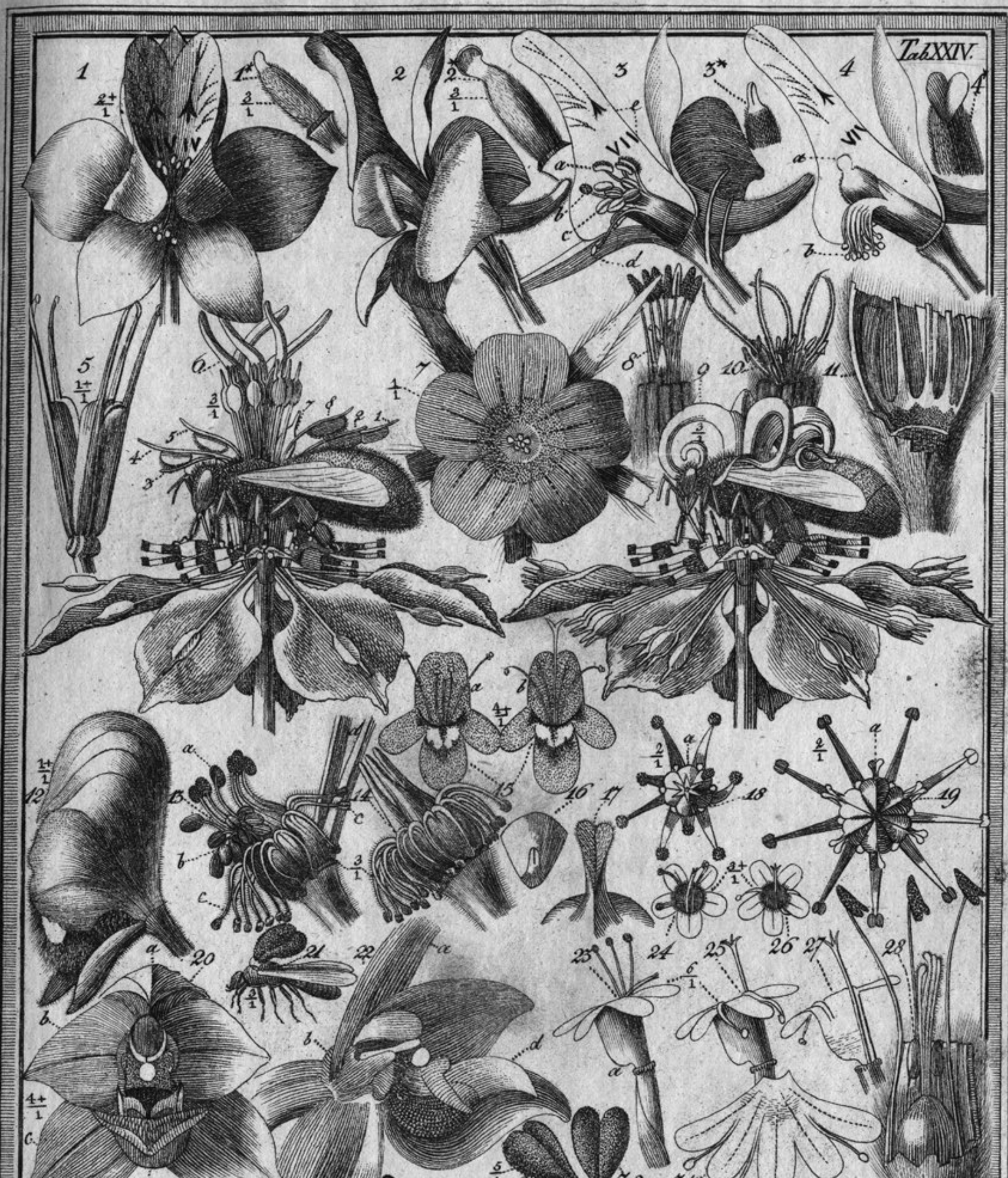
Sprengel's conclusions went against the prevailing dogma that pollen moves from anthers (male) to stigmas (female) within flowers, that is, that seed is produced by individuals mating with themselves (selfed). With hindsight, his evidence identified fundamental features of floral biology, including the fact that flowers are organs for attracting insects; that insects are rewarded with nectar; and that floral structure restricts inbreeding.[16]

Sprengel perhaps hoped that illustration would make his work attractive, bringing his results more attention than had been enjoyed by those

Title page of Christian Konrad Sprengel's *Das entdeckte Geheimnis der Natur* (1793) with its border of flowers and insects, including twayblade (II, XXVIII), meadow clary (XV) and European birthwort (XXI, XXIII). Metal plate with the border engraved by Wilhelm Arndt, based on illustrations by Sprengel, with text engraved by Carl Jäck.

of his predecessors. Entomologists showed some interest, but botanists largely ignored the book.[17] One botanist who noticed the work, but not its significance, was James Edward Smith, founder of the Linnean Society of London. Smith commemorated Sprengel in the name of the endemic Australian genus *Sprengelia* for 'his very ingenious work on the manner in which insects promote the impregnation of plants'.[18]

Just as Vaillant brought attention to the work of Camerarius, stimulating the creation of Linnaeus's Sexual Classification System, so Sprengel's and Kölreuter's work resolved a problem for Charles Darwin. Darwin's evolutionary ideas relied on variation within species maintained by natural cross-fertilization. Sprengel's data gave Darwin evidence for a process by which crossing between individuals could occur. Darwin's ideas were published, together with illustrations, in *On the Various Contrivances by Which British and Foreign Orchids Are Fertilized by Insects, and on the Good*


Tab. XXIV.

Effects of Intercrossing (1862), which concluded that 'Nature tells us, in the most emphatic manner, that she abhors perpetual self-fertilization.'[19] The study of pollination had gained scientific respectability, and the pioneering nature of Sprengel's work began to be understood.[20] However, Darwin's appreciation of Sprengel's work did not blind him to its shortcomings: 'How poor! Has no notion of advantage of intermarriage[.] Seems to think fact of insects being required at all, does not deserve any explanation.'[21]

Darwin's orchid

The Madagascan orchid *Angraecum sesquipedale* is one of the most celebrated plants in evolutionary biology because Darwin predicted its pollinator based solely on the form of its flower. In 1792 the botanist Louis-Marie Aubert du Petit-Thouars escaped the French Revolution to explore the French Indian Ocean islands (Madagascar, Mauritius, La Réunion). He returned to France a decade later with some six hundred drawings of plants and several thousand herbarium specimens. Among the plants he collected in Madagascar was an epiphytic orchid that had a large flower with white, waxy petals and a long, pale green spur. In 1822 he published his line drawings and named the plant *Angraecum sesquipedale* in recognition of the length of that spur ('one and a half feet'/50 centimetres).[22] Until the mid-nineteenth century this striking plant was known to botanists only from Petit-Thouars's illustrations.

In 1855 the Madagascar-based English missionary William Ellis, flattered with a reputation that 'no one has travelled in tropical regions, possessed of a greater love of nature', sent three living plants to his home in England, where they were cultivated and became sensations among English orchid growers.[23] When one plant flowered in 1857, Ellis's wife, Sarah, made 'an extremely clever sketch' of the flower, which was published as a wood engraving in the *Gardeners' Chronicle*.[24]

A few months before the publication of *Various Contrivances . . .*, Darwin received some flowers of this very rare *Angraecum* from the British orchidophile James Bateman. Darwin knew that orchid pollen is packed into sticky bundles, called pollinia, which become attached to floral visitors. Moreover, he knew that long-tongued insects visit orchids with floral spurs, where the nectar is found. He experimented with removing the

Magnified dissections of flowers of seven species, including the dark red helleborine (20, 22) with its pollinia attached to a pollinator (21, 29–30), from Christian Konrad Sprengel's *Das entdeckte Geheimnis der Natur* (1793). Engraving by A. Wohlgemuth, based on original illustrations by Sprengel.

Hand-coloured lithograph of *Angraecum sesquipedale* raised in cultivation by William Ellis at his home in Hertfordshire, England. Walter Hood Fitch's plate for *Curtis's Botanical Magazine* (1859) is dominated by the flower, measuring 'seven inches [18 cm] across, and the spur one foot [30 cm] in length', which is presented at natural size, together with a much reduced black-and-white sketch of the plant's habit in cultivation.

pollinia from *Angraecum* flowers. He could not do it until he forced a long, narrow tube into the floral spur. These observations led him to ask a question and make a prediction:

> What can be the use . . . of a nectary [floral spur] of such disproportional length? We shall, I think, see that the fertilization of the plant depends on this length and on nectar being contained only within the lower and attenuated extremity. It is, however, surprising that any insect should be able to reach the nectar: our English sphinxes [hawkmoths] have probosces as long as their bodies: but in Madagascar there must be moths with probosces capable of extension to a length of between ten and eleven inches [254–80 millimetres]![25]

A moth with such a proboscis was unknown in Madagascar, but Darwin predicted that it must exist. Moreover, he asserted that 'if such great moths were to become extinct in Madagascar, assuredly the Angraecum would become extinct.'[26]

Darwin's comments added fuel to the arguments generated by his *On the Origin of Species* (1859). The Scottish peer George Campbell, 8th Duke of Argyll, was provoked into writing *The Reign of Law* (1867), where Darwin's orchid-moth hypothesis was rejected in favour of supernatural explanations.[27] Alfred Russel Wallace, who had proposed a theory of evolution through natural selection independently of Darwin, began the defence of his friend against ducal assault with a barbed comment on study-bound naturalists:

> the noble author represents the feelings and expresses the ideas of that large class who take a keen interest in the progress of Science in general, and especially that of Natural History, but have never themselves studied nature in detail, or acquired that personal knowledge of the structure of closely allied forms . . . which are absolutely necessary for a full appreciation of the facts and reasonings contained in Mr Darwin's great work.[28]

Indeed, so confident was Wallace of Darwin's hypothesis that his defence included a lithograph, by the English illustrator Thomas William Wood, of a hypothetical hawkmoth pollinating *Angraecum sesquipedale* in a Madagascan forest.[29] In 1903 a hawkmoth with a tongue 225 millimetres (nearly 9 in.) long, as predicted by Darwin, was discovered in Madagascar; it was formally, and appropriately, named *Xanthopan morganii praedicta*.[30]

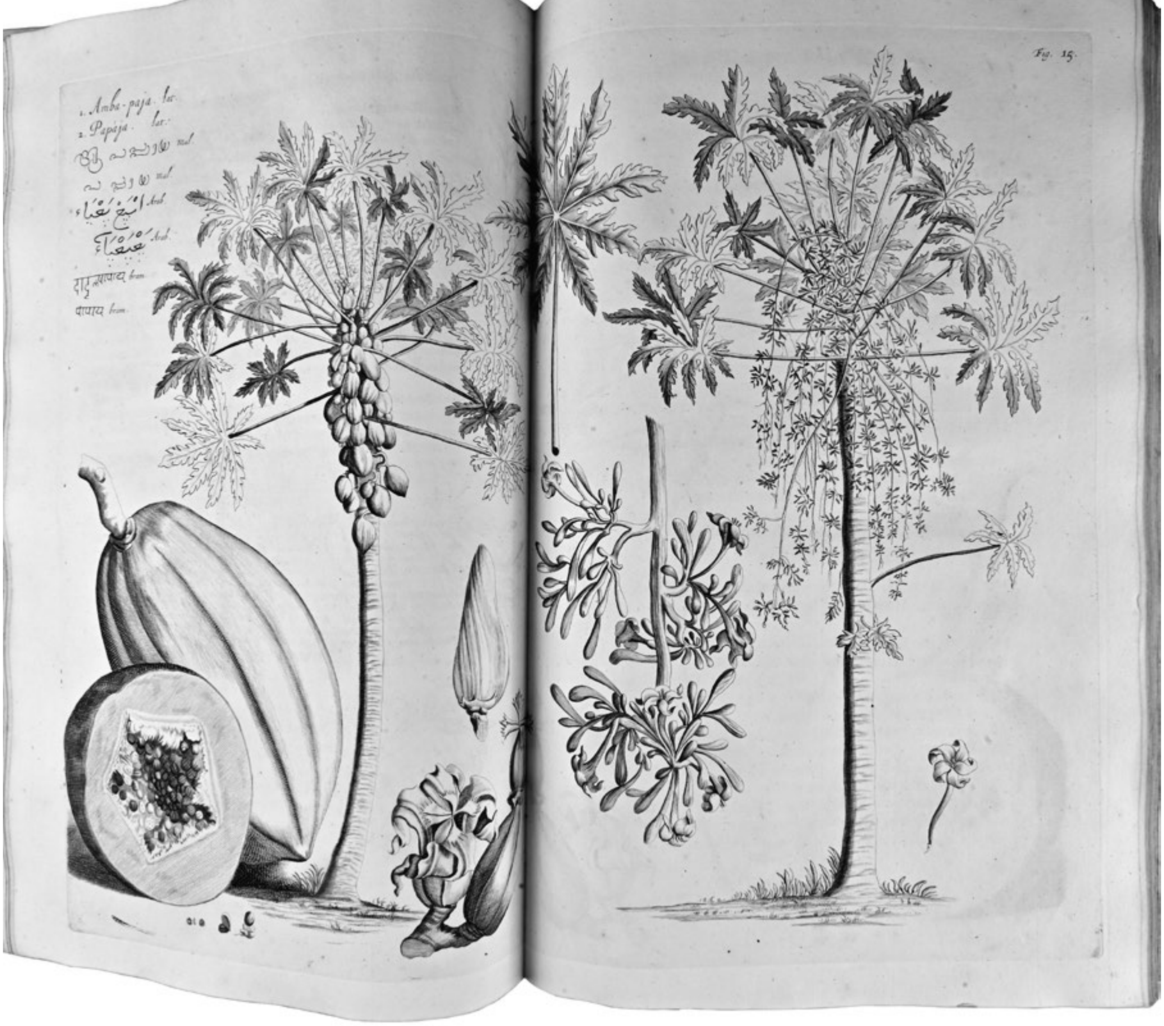
Scientifically, the discovery of the hawkmoth supported Darwin's hypothesis, while his statement that 'it would appear that there has been a race in gaining length between the nectary of the Angraecum and the proboscis of certain moths' introduced the important concept of co-evolution among organisms to the understanding of the evolution of patterns of variation and speciation.[31] Over the last century it has been confirmed that the hawkmoth does indeed pollinate the orchid – highlighting the power of both the scientific method and Darwin's evolutionary theory for understanding plant and animal diversity.[32]

Many roads

As Darwin's ideas took hold, flowers were no longer just beautiful organs for naming and classifying plants; they became fundamental to understanding the evolution, maintenance and generation of flowering plant diversity. Sprengel and Darwin demonstrated the importance of insects for circulating pollen, but could other things also move pollen among plant populations?[33] If so, could floral features be used to predict the identity of these pollinators? Are all flowers produced by a plant species the same, and if not, how are these different sorts distributed? Researchers, based in laboratories and libraries, could begin the search for answers to such questions by studying accurate botanical illustrations.

Generations of illustrators had recorded the diversity of the world's plants from the equator to the poles, seabed to mountaintop, and desert to tropical forest. Consequently, old images made to record the appearance of plants for many different purposes took on new significance as they were investigated, and the veracity of illustrators' observations implicitly judged. Illustrations were reinterpreted as recording patterns of variation, and reviewed for rigorous evidence to support explanations of the processes that had led to the evolution of the forms they captured. For example, floral illustrations could be investigated in the light of hypotheses that their forms were intimately associated with their function. However, such questions moved beyond a reliance on qualitative data

Hand-coloured engravings of two North American monkeyflower species, the insect-pollinated yellow-flowered musk monkeyflower (left) and the bird-pollinated red-flowered scarlet monkeyflower (right). Both species were introduced to British gardens in the early nineteenth century by David Douglas; William Jackson Hooker commented that the scarlet species was 'certainly the most beautiful . . . though its beauty is somewhat diminished by the reflexed position of the scarlet lobes of the corolla'.[34] The feature is linked to the pollination mechanism, which was unknown to Hooker.



Engraving of male ('amba-paja'; right) and female ('papaja'; left) papaya trees, from Hendrik Adriaan van Rheede tot Drakenstein's treatise on medicinal plants *Hortus malabaricus* (1678–93), showing a common leaf and details of flowers, fruit and seeds at various scales. The illustrations were made on the Malabar Coast of India by artists who were evidently familiar with this introduced fruit tree from the Americas.

from illustrations. Quantitative data was needed; things had to be counted and measured.

The papaya trees depicted in the woodcuts used in l'Écluse's *Curae posteriores* (The Latter Works, 1611), and copied in Gerard's *Herball* (1633), have the habits of trees familiar from European landscapes – the illustrator relied on second-hand information. However, the characteristic appearance of the male trees, with their flowers arranged on long, slender stalks, and of the female trees, with fruit in tight clusters, is accurately shown. By the end of the century illustrations made by artists with first-hand experience of papaya trees depicted habits accurately and were beginning

to show floral details. With more knowledge, papaya trees have also been discovered that have male and female flowers on the same individuals; given their increased reliability as fruit producers, this sort of tree is grown in most papaya plantations today.

Gerard gave male and female papaya plants different names, taking his lead from l'Écluse: 'Mamoera mas', the 'male dug tree'; and 'Mamoera foemina', the 'female dug tree'.[35] In the light of present knowledge, l'Écluse got the separation of the sexes correct. However, in other cases, where separate male and female plants were given different names, the sexes were wrongly assigned. For example, robust, biologically female hemp plants were called 'Cannabis mas' (male cannabis), while delicate, biologically male plants were called 'Cannabis foemina' (female cannabis). In some cases, such as the European black bryony, illustrators accurately depicted the differences between male and female plants without giving them separate names.

Hand-coloured copper engraving of the holly from Philip Miller's *Figures of the Most Beautiful, Useful, and Uncommon Plants Described in the Gardeners Dictionary* (1755–60). Richard Lancake's illustration, engraved by Thomas Jefferys, shows a fruiting sprig with hermaphrodite flowers. Holly has separate male and female plants. When Miller stated trees 'produce only male Flowers . . . not succeeded by Fruits, and others whose Flowers are hermaphrodite, and have Berries succeeding them', he probably assumed aborted male parts of female flowers were functional.[36]

Spice of life

Typological approaches to botanical illustration, focusing on floral features that distinguish species, are useful for comparing flowers, which may lead to testable hypotheses about floral biology. However, typological illustrations blur the variation within species by de-emphasizing features that make plants individual. Furthermore, heritable within-species variation is important as the raw material of plant evolution and breeding.

We see individuality in humans, our pets and perhaps some other mammals and birds, but we often have difficulty recognizing it in plants. However, close examination of botanical illustrations of the same species, made by different artists working in different regions, may show individual variation, such as that in habit, height or hairiness, unassociated with

the styles of individual illustrators. Differences may be because of genes, the environment, or the way in which genes are expressed in specific environments. Consider the case of common whitlow grass, a Eurasian member of the cabbage family whose native range extends from the Atlantic Ocean into Central Asia. This early spring-flowering plant of open areas is highly variable. Individual plants differ in such features as height, leaf shape and hairiness, and flower and fruit size. Experiments in the 1860s found at least 53 distinctive sorts that retained their features when grown together in cultivation, and, when seed were planted, more of the same sort was produced.[37] That is, the differences had genetic bases that were inherited from one generation to the next.

Leaves are an example of an organ that varies. Different types of leaf may be produced on the same plant at different developmental stages (heterophylly). The decorative leaf of ivy, with its hand-like shape, five triangular lobes and heart-shaped base, grows on juvenile stems that creep along the ground or climb trees and walls. By the time the stems have

Lithograph showing variation in the features of common whitlow grass across its European distribution. The features are rosette form (1–4), hairs (5a–e), flowers (6–9) and habit when flowering and fruiting (10–15). Such variation has led to suggestions that the common whitlow grass be split into many, more tightly defined species. Carl Friedrich Schmidt made the lithograph from drawings and photographs by Felix Rosen.

4576. *Ranunculus* (*Batrachium*) *aquatilis* L.

matured and are producing flowers, they are usually producing unlobed leaves with wedge-shaped bases.[38] Heterophylly may also be associated with environments. Many white-flowered aquatic crowfoots (such as *Ranunculus aquatilis*), which are in the same genus as yellow-flowered terrestrial buttercups (such as *R. acris*), produce lobed floating leaves and/or highly divided submerged leaves. Species from mud and shallow water have floating leaves only, species from fast-flowing or deep water have submerged leaves only, while species of intermediate water bodies may have a mixture of floating and submerged leaves.

Florists' eucalyptus sprays are the juvenile shoots of many different Australian *Eucalyptus* species. As a botanist interested in the diversity of southeast Australian native trees, the Anglo-Australian Joseph Henry Maiden wanted to know how tree populations varied across their native ranges. He was aware that such patterns were not only botanically interesting, but could be economically valuable to Australian foresters. Maiden's best-known works are the seven-volume *The Forest Flora of New South Wales* (1902–25) and the eight-volume *A Critical Revision of the Genus Eucalyptus* (1903–33). Both were highly illustrated with full-page lithographed black-and-white plates by the Anglo-Australian botanical illustrator Margaret Lilian Flockton, the first botanical illustrator to be employed by the Royal Botanic Gardens, Sydney.[39] Across her plates, Flockton demonstrated the diversity of features associated with leaves, flowers and fruit within and among *Eucalyptus* species.

In nineteenth-century Europe, fruit trees attracted artists to illustrate expensive books aimed at wealthy garden and orchard owners. Other fruit, such as blackcurrants and gooseberries, were also the subject of illustrated books or horticultural journals, for example, the French naturalist Claude-Antoine Thory's *Monographie; ou, Histoire Naturelle du Genre Groseillier* (A Natural History of the Gooseberry, 1829).[40] However, most people who selected and grew gooseberries would hardly be able to afford such lavish productions. By the 1830s, as variation within gooseberries for fruit flavour, maturity date and size was selected, more than seven hundred named cultivars were available in Britain alone.[41] Moreover, there was a 'steady increase in the size of the fruit'; wild gooseberries weigh approximately 8 grams (⅓ oz), but by 1786 this had doubled, and in 1852 a fruit weighing 58 grams (2⅓ oz) was recorded.[42] These transformations were affected by

Variation in form, aerial and submerged leaves, flowers and fruit of common water crowfoot growing in different habitats. Hand-coloured lithograph by an unknown artist from Ludwig Reichenbach's *Icones florae Germanicae et Helveticae* (Images of German and Swiss Flowers, 1838–9)

competition among working-class gooseberry clubs in northern England.[43] Club members – mostly workers in the cotton mills, mines and potteries of the emerging industrial economy – vied for prizes of a few shillings and kettles, crockery or cutlery. Competitors, winners and prizes were recorded annually in the unillustrated *Gooseberry Growers' Register*. For example, in 1856 more than 7,500 fruit representing nearly three hundred cultivars were shown in over 180 competitions, and the most popular cultivar was the red-fruited 'London'.[44] By the 1920s competitive gooseberry growing had succumbed to a North American gooseberry pathogen and the social consequences of the First World War.

Today, the only evidence we have of some nineteenth-century gooseberry cultivars, and those of other fruit, are botanical illustrations.

Six apple cultivars ('Striped Holland Pippin', 'Marygold', 'Sullenworth Rennet', 'Saint Germain', 'Watkin's Large Dumpling' and 'Beauty of Kent'), depicted in an aquatint and stipple engraving, from George Brookshaw's *Pomona Britannica* (1804–12).

Lithograph of Margaret Lilian Flockton's illustrations of three eucalyptus species (1–2 southeastern Australian gully gum; 3–4 Filipino rainbow gum; 5–13 eastern Australian mugga ironbark) for Joseph Henry Maiden's *A Critical Revision of the Genus Eucalyptus* (1914). Flockton's complex, visually engaging plates display much detailed information on variation associated with the shapes of such features as juvenile and mature leaves, flower buds and fruit.

However, for most extinct variations there are not even illustrations, just lists of evocative names reflecting the concerns of people interested in fruit cultivation. The illustrations have become a time capsule, an opportunity to see variation that was once thought worth cultivating, propagating and immortalizing.

Reconstructing rarities

Illustrators may have to work with limited evidence, using their knowledge and experience, when (re)arranging and reconstructing whole structures from fragmentary materials. Well-founded predictions, based on fragments, about the appearances of whole structures can be made by skilled illustrators who understand the patterns and limits of natural variation in organs, and how one organ relates to another. Yet some features cannot be reconstructed from preserved fragments – most notably colour. Beyond plant sciences, familiar examples of using fragmentary data include pottery shards to rebuild Minoan vases, a skull to reconstruct Richard III's face, or fossils to create the appearance of dinosaurs and dioramas of the landscapes in which they lived. In plant sciences, there are three situations in which fragmentary materials are common: ethnobotanical objects; herbaria; and fossils.

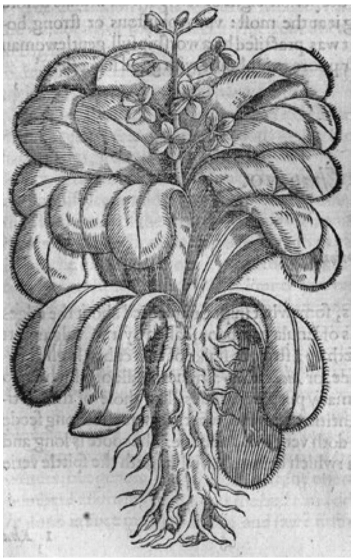
Since antiquity, medicinal plants, roots, bark, leaves and fruit have been traded and moved, with consumers often having little knowledge of the plants from which even strategically essential medicines come (as with quinine bark). This is a situation that continues to the present day. For example, an ethnobotanist with the common name of a medicinal root collected in a marketplace faces the challenge of placing the root within localized and globalized knowledge systems, together with discovering the living plant's identity and how it is traded and grown.

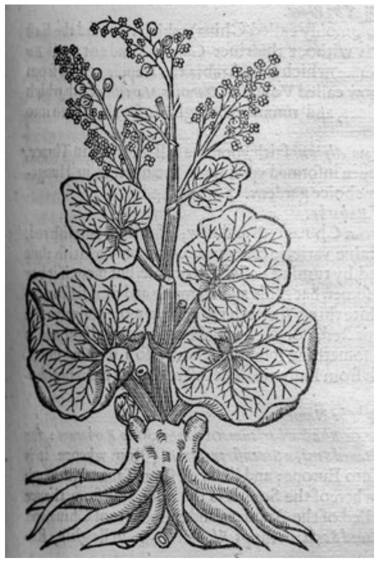
Consider poisonous, nutritious and medicinal rhubarb – the plant from 'beyond the Volga' and the butt of playground humour.[45] Rhubarb leaves arise directly from the ground; the stout, pink-red stalks are used for making desserts and wine, while the large green blades are toxic. Underground, the leaves emerge from buds that circle the top of a short stem (rhizome) with mild laxative properties. Traditionally, rhubarb rhizomes were imported into Europe under names that indicated the place of export,

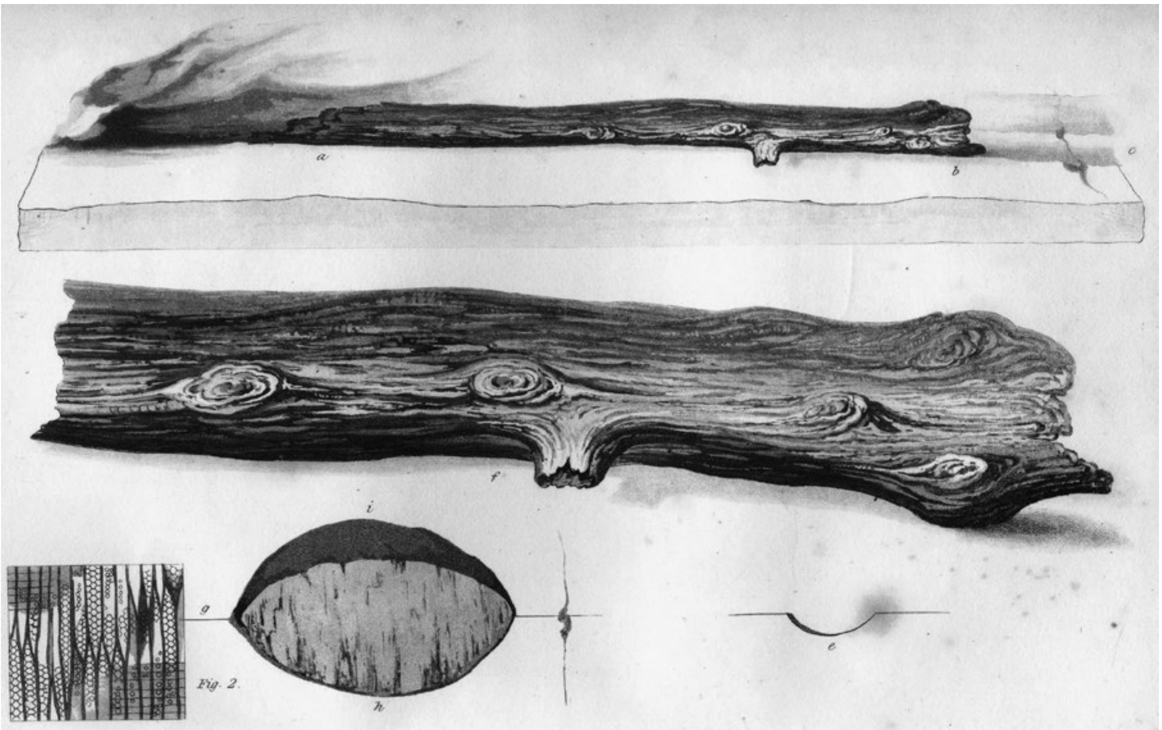
even though everything ultimately came from China. Overland, Russian rhubarb came from the Russia-China frontier, while Turkish rhubarb came from the eastern Mediterranean. By sea, east Indian rhubarb came from Southeast Asian ports.

With so many different sources for an ancient, medically important plant, but knowledge based only on dried rhizomes, people naturally wanted to know more about the plant and how to grow it. Furthermore, growing 'true' rhubarb in Europe could also bring great financial rewards. In 1597 John Gerard published woodcuts of cabbage-like '*Rhabarbarum florens*. Flowring Rubarbe' taken from the 1565 edition of Pietro Andrea Mattioli's *Commentarii in sex libros Pedacii Dioscoridis*, but by 1633 Gerard's editor (Thomas Johnson) had dismissed this image as being of the '*Rha verum antiquorum*. The true Rubarbe of the Antients'.[46] Instead, Johnson published a crude copy of a woodcut from Parkinson's *Paradisi in sole* (1629).[47] Parkinson juxtaposed a woodcut of a dried rhizome (taken from Gerard's herbal of 1597) with a woodcut clearly based on an illustration drawn from nature. The basal leaves and those on the flowering stem, together with the buds on top of the rhizome, are naturalistic, and allow the plant to be placed in the rhubarb genus *Rheum*, but the roots and flowers are highly stylized. However, Parkinson makes this visual correlation only between the rhubarb rhizome of commerce and a plant growing in his garden.

Early modern rhubarb woodcuts linking a plant known from dried plant parts with the living plant. John Gerard's woodcut of '*Rhabarbarum florens*' from *The Herball* (1597; left) has none of the characteristics associated with the rhubarb family. John Parkinson's woodcut of '*Rha verum antiquorum*' from his *Paradisi in sole* (1629; centre) shows important characteristics of the family with biologically realistic associations between the above- and below-ground parts, despite the superficial depiction of flower arrangements. The illustrator of the 1633 edition of Gerard's *The Herball* (right) has crudely redrawn Parkinson's image, producing a reversed image, erasing most of the characteristic features in '*Rha verum antiquorum*' and implicitly disassociating the above- and below-ground parts.







A 22-metre-long (72 ft) trunk of the fossil *Pycnophyllites brandlingi*, recovered from coal measures (strata) near Newcastle upon Tyne in the north of England. This gymnosperm grew in tropical coal swamps during the Carboniferous period (about 300 million years ago). In the field, an unidentified artist 'took a drawing before any attempt was made to move it from its bed', but, 'notwithstanding every possible care and anxiety to preserve it whole, it fell to pieces, so that the largest fragment obtained is not above eighteen inches [45 centimetres] long.'[48] The etched plate was published in John Lindley and William Hutton's *The Fossil Flora of Great Britain* (1831).

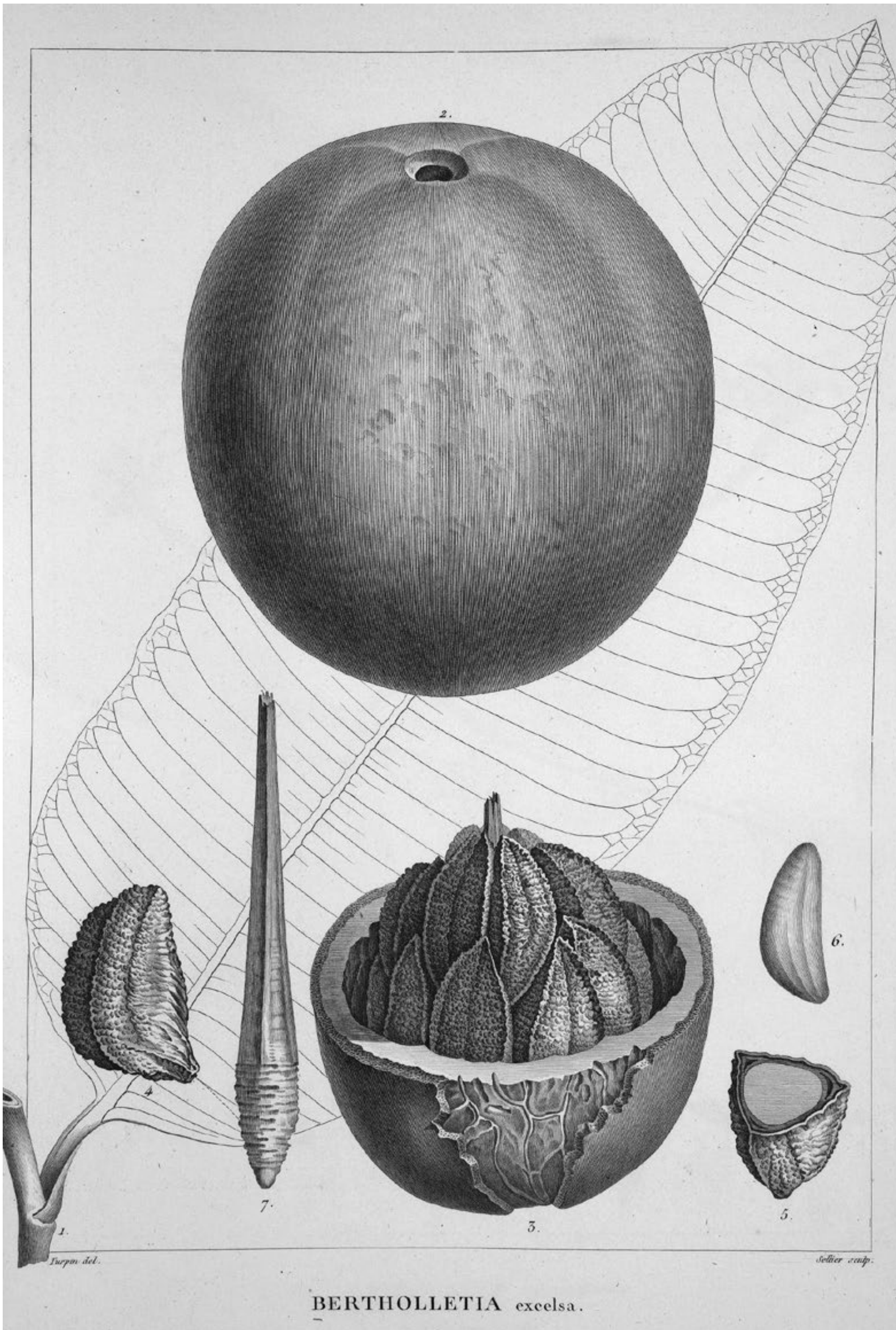
Many botanical illustrations are made from living specimens or sketches, but herbarium specimens have also provided the models for people illustrating new species. The French botanist Augustin François César Prouvençal de Saint-Hilaire travelled in southeastern and southern Brazil between 1816 and 1822, gathering tens of thousands of herbarium specimens, which he returned to France.[49] He spent the rest of his life working on these collections. More than 190 specimens were used by the French botanical illustrators Pierre Jean François Turpin and Eulalie Delile to make the illustrations, converted into exquisitely engraved plates, for Saint-Hilaire's three-volume *Flora brasiliae meridionalis* (1825–32).[50] Each line-engraved plate typically comprises the whole plant or, for larger plants, a shoot, plus dissected details of organs, such as flowers and fruit. The illustrators made no attempt to draw the plant as it appears in life, but neither did they merely draw a herbarium specimen. They brought their skill and experience to giving the images three-dimensional structure as far as they believed justified. Researchers have estimated that approximately half of all the planet's unnamed flowering plants have been collected, but that they lie unnamed, or incorrectly named, in the world's botanical

collections.[51] Unless these species are re-found living in the wild, scientists and their illustrators will have no choice but to use dried specimens as models should these species ever be described and illustrated.

Illustration that accompanied the description of a new species of Chinese tree, *Actinotinus sinensis*, in 1888. Drawings were made and lithographed at Kew by Matilda Smith, based on a herbarium specimen found in China by a collector working for Augustine Henry. The illustration shows none of the 'artful insertion' used to construct the specimen that Daniel Oliver blamed for his blunder in creating a new species from a fake specimen.

Palaeobotany – the study of fossil plants – confronts botanical illustrators with specific problems, such as fragmentary material, where (unlike with herbarium specimens) connections among fragments are likely to be unknown.[52] Plant fragments, trapped in sediment, may eventually fossilize as isolated roots, stems, leaves, flowers or fruit. The English naturalist Edmund Tyrell Artis was employed by William Wentworth-Fitzwilliam, 4th Earl Fitzwilliam, one of the richest men in early nineteenth-century Britain. Between 1816 and 1821 Artis made underground explorations of the earl's Yorkshire mines, building a personal fossilized-plant collection of more than 1,000 specimens in the process.[53] Some of these were illustrated across 24 black-and-white, stipple-engraved plates in his *Antediluvian Phytology* (1825; reprinted in 1838).[54] These exceptional palaeobotanical illustrations are accurate representations of the specimens from which they were derived; Artis made no attempt to represent the fossils as they may have appeared in life. Artis, a protégé of the English theologian and geologist William Buckland, fell out with his mentor after he refused to follow the standard practice of the period and interpret his fossil discoveries within a scriptural context.[55] In the mid-nineteenth century the plates were republished by Henry George Bohn as hand-coloured prints – somewhat reminiscent of the present-day vogue for applying false colour to black-and-white photographs.[56]

Reconstruction always comes with a risk of misinterpretation. In 1888 the English botanist Daniel Oliver formally named a new Chinese tree – *Actinotinus sinensis* – based on a specimen collected by the Irish plantsman and sinologist Augustine Henry in the province of Hubei,



Turpin del. Sellier sculp.

BERTHOLLETIA excelsa.

De l'Imprimerie de Langlois.

central China. At the Royal Botanic Gardens, Kew, the illustrator Matilda Smith drew and lithographed the new species. Oliver claimed with ecstatic authority that 'it is certainly one of the most remarkable of the many important additions to the Chinese Flora which we owe to his [Henry's] persistent energy.'[58] However, the following year Oliver was forced into a retraction. The specimen proved to have been faked, a 'trick played [on] us by one of Dr Henry's Chinese collectors. It is made up of the inflorescence of a *Viburnum* inserted artfully into the terminal bud of *Aesculus sinensis* [Chinese horse chestnut].'[59] Henry's anonymous collector cannot be blamed for Oliver's decision to name a new species. Neither he nor Smith examined the specimen carefully enough – perhaps trusting too much to Henry's botanical skill, veracity and reputation.

Scientific reconstructions rely on the integrity and professionalism of botanical artists working at the limits of their knowledge. Reconstructions are hypotheses, open to argument, revision and indeed abandonment. Perhaps initially made in black and white, such images increase in appeal when colour is added, leading to an impression of greater confidence in the illustration than the illustrator may have intended. Viewers must therefore be aware of the limits of such reconstructions, remembering that they are hypotheses, and not become beguiled by their visual appeal.

Mastering geometry

With its squat trunk, massive lower boughs and repetitions of stocky branches, a deciduous oak tree is immediately recognizable in an English winter landscape. As one gets closer to the tree, other patterns emerge, such as the splitting and vertical fissuring of the bark, the clustering of buds at the tips of the twigs, and the arrangement of bud scales. With spring, additional patterns unfurl as the buds break. Bilaterally symmetrical leaves become recognizable by their outlines, bases, tips and margins, and the way they are arranged on the stem. Closer still, the epidermal cells covering each leaf are patterned like floor tiles, while, deep inside the trunk, the packaging of wood cells reflects patterns of seasonal growth and ageing. Although centuries of fluctuations in temperature, water and light, and biotic interaction with insects and disease, have left their marks on these patterns, the oak tree remains recognizable. The patterns, which give the

Copperplate engraving of the cannonball-like fruit of the Brazil nut, which was 'as big as a child's head', set against one of the tree's leaves, from Alexander von Humboldt's *Plantes équinoxiales* (Equinoctial Plants, 1808).[57] Pierre Jean François Turpin's illustration, showing the three-dimensional packing of the seeds inside the fruit, was engraved by François-Noël Sellier. The flowers are not shown, since Humboldt did not observe these in the field.

oak its gestalt or 'jizz', can be difficult to put into words. However, a skilled botanical illustrator may be able to capture such patterns in only a few lines – just as a cartoonist might summarize an individual human subject.

For centuries botanical illustrators have portrayed these patterns within and among the planet's plants. Such patterns led Goethe to write about the origins of plant organs, the French scientists Louis-François and Auguste Bravais to study crystallography, and the German artist Karl Blossfeldt to create sculptural monochrome photographs.[60] An illustrator's ability to transfer the shapes of, and relationships among, three-dimensional structures on to two-dimensional surfaces is central to their skill. Indeed, one means of judging the scientific quality of a botanical illustration, and hence an illustrator's mastery of their craft and ability as an observer, is to look for the accurate depiction of natural patterns modulated by the environments in which plants grow.

One natural plant pattern that has been discussed for centuries is the spiral, or the illusion of a spiral: so-called phyllotaxis.[61] For example, in oak, there is a repeating spiral of five leaves with approximately every two full turns of the stem. The head of an annual sunflower has clockwise and anticlockwise intersecting spirals of tiny flowers. In the cones of spruces and the fruit of pineapples, three sets of intersecting spirals surround a cylinder.[62]Many such spirals have a specific mathematical relationship at their heart: the Fibonacci series – 0, 1, 1, 2, 3, 5, 8, 13, 21 . . . The series, known to ancient Indian mathematicians, is named after a thirteenth-century Italian mathematician, Leonardo Fibonacci of Pisa. In it, each number is the sum of the two previous numbers. Furthermore, dividing one number by the subsequent number produces another number series: 1, 0.500, 0.666, 0.600, 0.625, 0.615 . . ., whose values converge on an irrational number known as phi or the 'golden number', 'golden ratio' or 'golden mean'. When people search for this number in the anthropogenic and natural worlds they find it, which frequently leads to spurious mystical associations. Biologically, the number describes the optimal spacing between adjacent repeated units.

Vitalism, the belief that living things are governed by different principles from those of non-living things, is rejected by careful examination of botanical illustrations. Combing through centuries of such illustrations, the repetition of similar patterns among diverse plants from across the planet becomes obvious. These natural, repetitive patterns are reproduced by the

Hand-coloured copperplate engraving of a female cone of stone pine, together with magnified details of the scales and seeds, from Aylmer Bourke Lambert's *A Description of the Genus Pinus* (1803). Ferdinand Bauer's illustration, which was engraved by Thomas Warner, shows three spirals (clockwise, anticlockwise and vertical) of scales on the cone.


a
b
c
d
e
e
f
G
a

implementation of simple mathematical rules. The challenge for scientists is to see beyond the beauty of rules and images, to develop testable, mechanistic hypotheses – using physical, chemical and genetic principles – to explain the presence of such patterns in living plants.[63]

EXPERIMENTAL PLANT SCIENCES over the past two centuries have challenged traditional botanical illustrators, whose work is based on using pencil, ink and paint to record static, macroscopic images. During the twentieth century film and digital photography took over in the field, herbaria and laboratory. Photography as a 'true', unbiased means of illustrating plants has matured into the explicit realization that it involves the manipulation of light and shade, editing and data presentation – skills practised by botanical illustrators for centuries.

A major use of today's digital techniques is the routine capture of time-lapse images. Towards the end of his life Charles Darwin became interested in the movement of plants. To create time-lapse images, he resorted to having his assistants meticulously trace the tracks of leaf and stem movements on to panes of glass.[64] In contrast, today cell and developmental biologists, who investigate the structure and expression of genes in cells and organs, use coloured chemicals to track the movement of specific genetic and chemical activities inside cells. Time-lapse images collected by instruments connected to computers reveal when and where genes are switched off in cells, and how compounds move within and among organs in real time. Traditional botanical illustrators would find these beautiful, mesmerizing images impossible to capture rigorously. Yet botanical illustrators' skills remain essential for communicating complex scientific ideas and information.

nine

SWEAT AND TEARS

> Little by little experience, the most efficient teacher of all things . . . degenerated into words and mere talk. For it was more pleasant to sit in a lecture-room engaged in listening, than to go out into the wilds and search for the various plants at their proper season of the year.
>
> PLINY THE ELDER, *Natural History* (*c.* 70 CE)[1]

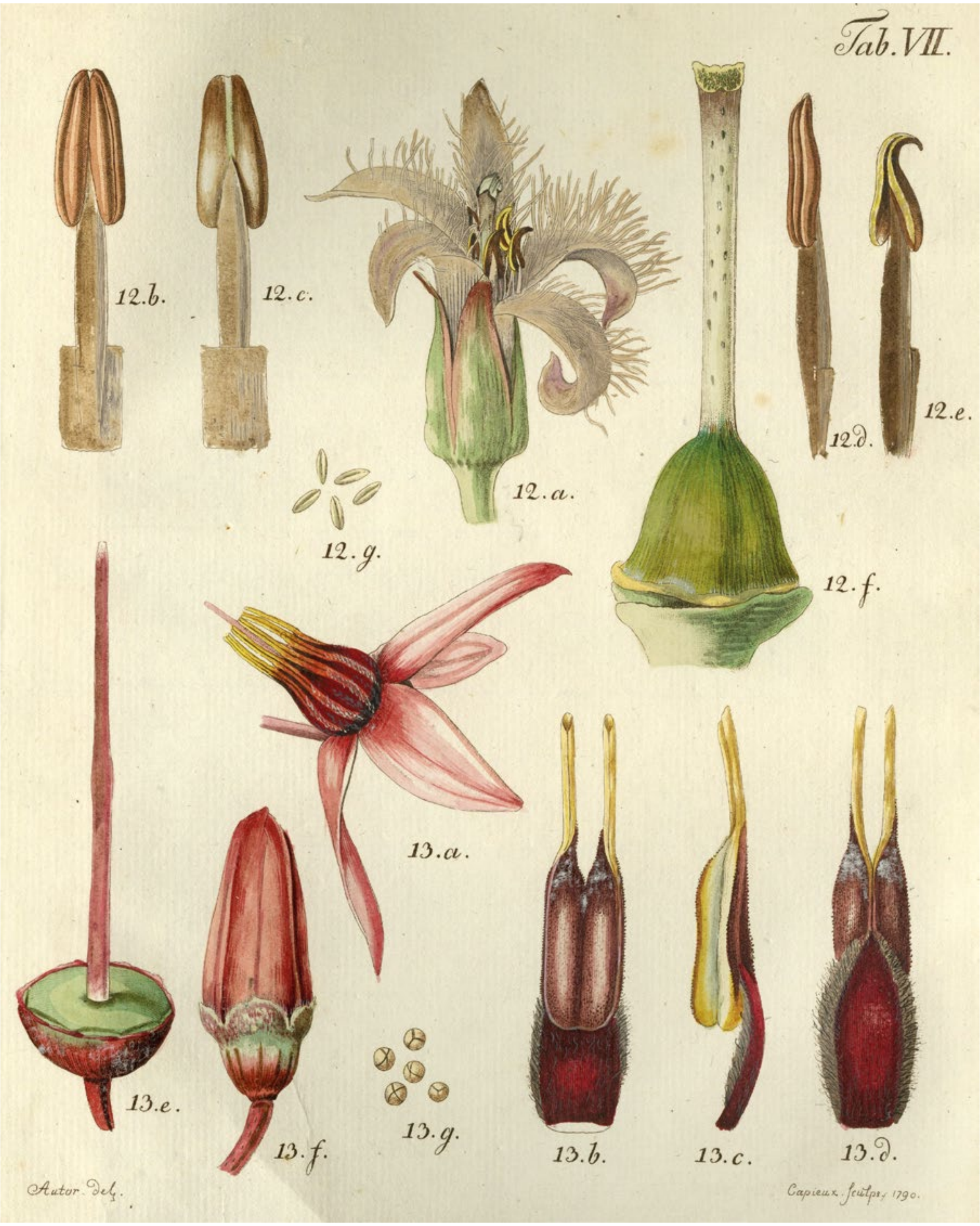
'Plant blindness' is a cultural or perhaps hardwired tendency for humans to ignore plants within landscapes or to overlook their significance in our lives.[2] Education may teach us to appreciate plants, although daily fusillades of such clichés as lilies, roses and sunflowers risk bringing about botanical desensitization. Consequently, even botanically novel images are cast in the hyperbolic language of the marketplace – an arms race of the spectacular – where comparisons are zoological, superlatives are rife and anthropocentric adjectives, such as 'weird', 'monstrous' or 'mysterious', thrive to grab the attention of sometimes reluctant, fickle audiences. In the nineteenth century at least one North American teacher of botany warned of the 'eclipse of the naturalist by the artist', urging moreover that attractiveness must never trump accuracy: 'beautiful drawings must be allowed to be no less accurate than those which are merely diagrammatic.'[3]

Many people are put off learning botany, which is reinforced by the perception that it is necessary to learn extensive, complex and apparently pedantic terminology and long lists of plant names. Neither is necessary for one to be interested in botany, although the essential language of botany is probably no more difficult to acquire than that associated with any other

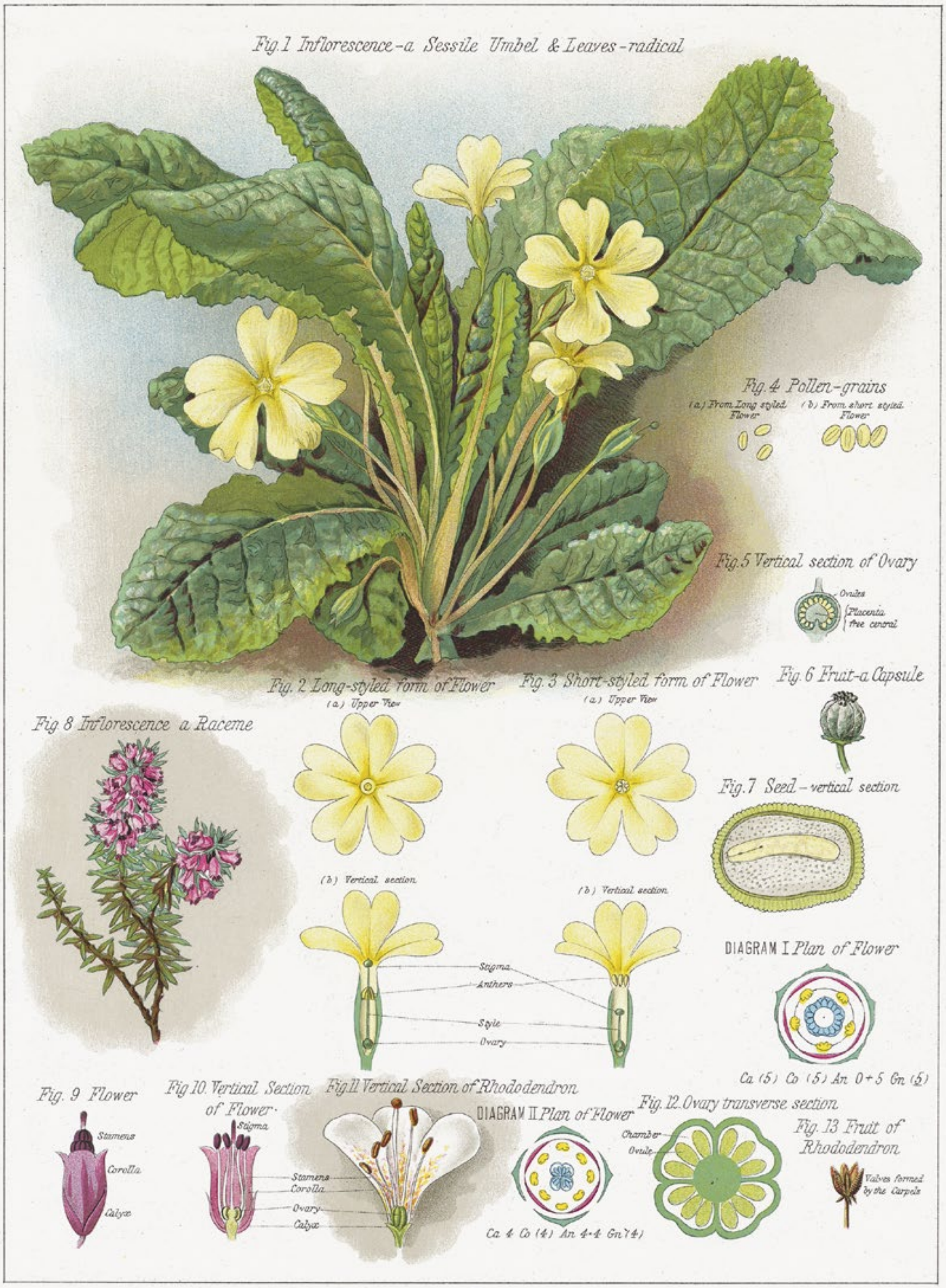
technical endeavour. The French philosopher, journalist and schoolmaster Ernest Bersot complained, 'how many times I have tried to become a botanist, and each time I have been defeated.'[4] For him, the reason was clear: 'botany is one of the most deceptive sciences. Because flowers are charming, one imagines that it is charming too; we are quickly disabused. Why is that? . . . It's that the scientists have been thinking about themselves and not about us.'[5] The Swiss philosopher Jean-Jacques Rousseau took a similar view: 'nothing is more pedantic or ridiculous, when a woman, or one of those men who resemble women, are asking you the name of an herb or flower in the garden, than to be under the necessity of answering by a long file of Latin words . . . an inconvenience sufficient to deter such frivolous persons from a charming study.'[6] However, much botanical education is neither literary nor formal, but visual and informal – based on opportunities to talk about plants, to see and cultivate living plants, or to study and make accurate botanical images.

Ferdinand Bauer's watercolour of the European olive, which was probably used by John Sibthorp for demonstration purposes during his botanical lectures at the University of Oxford in the late 1780s: 'Our Olive Tree tho' it produces its flowers, seldom ripens its Fruits & that you may have a more perfect Idea of it I shall show You the fructification in a drawing.'[7] Watercolour made in Oxford, based on a pencil sketch prepared in the eastern Mediterranean during Bauer and Sibthorp's travels in 1786–7.

Imagery in botanical education encourages students to learn to see, to interpret structures and to be critical. More widely, images are also part of botanical showmanship. Eighteenth-century university teachers circulated original or published botanical images among small groups of students, especially when plants were too exotic for cultivation in glasshouses or, inconveniently, flowered outside teaching seasons. From the early nineteenth century onwards, cheap, rapid processes for reproducing images put illustrations within the reach of audiences thirsty for botanical information. At the close of the century photographs were replacing wood engravings as the preferred means of making cheap illustrations for popular publications. Moreover, as audiences for botanical knowledge expanded and public lectures became entertainment, commercial wallcharts, models and lantern slides offered great didactic possibilities to



Hand-coloured, didactic engravings of floral dissections, including pollen grains, of the bogbean (above) and the bog cranberry, from August Batsch's *Analyses florum* (Floral Analyses, 1790). Batsch's own illustrations were engraved by the German illustrator Johann Stephan Capieux.



Engraved, Printed and Published by W. & A.K. Johnston, Edinburgh.

teachers and publishers alike. However, in formal practical teaching settings and field classes, students were still encouraged to adopt the principles of botanical illustration to record their observations. The pedagogic tenet was that physical drawing, coupled with a receptive mind, forced a student to attend to detail, interpret observations and, importantly, ask questions.

The drawing-room of princes

At the turn of the nineteenth century ideas that had circulated in the Enlightenment were translated into consumer goods that moulded the intellectual and economic life of Britain. Furthermore, the consequences of revolutionary events during the last quarter of the eighteenth century were overshadowed by Napoleon Bonaparte's ambitions in continental Europe.

Against this background, an independently wealthy Englishman, Robert John Thornton, 'a Quack in Botany as well as in Medicine', became convinced that his homeland was losing her botanical prestige among European imperial powers.[9] He developed his medico-botanical interests at the University of Cambridge under the tutelage of Thomas Martyn, a pioneering teacher of Linnaean botany in England.[10] However, Linnaeus's ordering of Creation into a 'chain of being' also appealed to Thornton's political views and his beliefs about the place of humans in the natural world.

Thornton conceived a large-format part-work, illuminated with seventy plates, which would explain Linnaeus's classification system, re-establish Britain's botanical supremacy and preserve the skills of botanical illustrators. His *A New Illustration of the Sexual System of Carolus von Linnaeus* started to trickle out from the printing press in 1799, and the final part, the *Temple of Flora*, was published in 1807. Thornton's desire was 'to unite *botanical correctness* with *picturesque effect*' in a 'National Botanical Work'.[11] Despite his assertions that everybody should learn about botany, Thornton's work was not directed at 'Cabbage-planters; but to the best refined . . . who delight in Gardens and aspire to the perfections of the Arte'.[12]

Each part of the *Temple* includes coloured, picturesque plates associated with letterpress text. The plates from the *Temple* are immediately recognizable. Set against fictional landscapes, bold, often flamboyant, plant

A botanical teaching manual, Daniel M'Alpine's *The Botanical Atlas* (1883), aimed at university students, showing the structures of primrose, rhododendron and bell heather, where 'full directions are given along with the drawing for their proper examination.'[8] The two different floral forms found in primrose populations, just six years after Charles Darwin drew attention to the phenomenon in his *The Different Forms of Flowers on Plants of the Same Species* (1877), are clearly presented.

'Large flowered Sensitive Plant', a species in the leguminous genus *Calliandra*, is widespread through tropical Mexico south to Guatemala and Honduras. The flowers, which are probably pollinated by bats (although the plate implies that birds are involved), open in the early evening. This is likely to be the first published coloured illustration of the species. Aquatint, stipple and line engraving, issued 1 December 1799, by Joseph Constantine Stadler, based on an original oil painting by Philip Reinagle and published in Robert John Thornton's *Temple of Flora* (1807).

portraits are depicted as if the observer is looking at them slightly from below – as one might view a wall-mounted portrait. With Thornton's characteristic hyperbole, advertisements emphasized that 'all the most eminent English Artists' had been employed in the creation of the work.[13] Many of the engravers, who worked in a variety of techniques including mezzotint, stipple and aquatint, were at the zenith of their craft, but the five painters of Thornton's plants, other than Sydenham Teast Edwards, were largely unknown for their botanical work. Thornton's preferred artists were the portraitist and animal and landscape painter Philip Reinagle, and Peter Charles Henderson, who wrote a minor work on flower drawing.[14] The models used by Thornton's artists probably came from living plants cultivated in gardens around London. Moreover, since the printing

and colouring of the plates occurred over nearly a decade, each copy of the *Temple* is probably unique.

The extent of Thornton's dreams went beyond his purse. Between 1811 and 1813, in an ill-judged attempt to raise funds to continue his scheme, he ran a 'Royal Botanical Lottery' that had been authorized by Parliament. Twenty thousand two-guinea tickets (about £90 in 2022) were issued; the prize was to be all original material related to the project, include the oil paintings and printing plates. Thornton's gamble failed. He lost everything associated with the production of the *Temple* and his remaining fortune – he was ruined. He blamed his woes on the war-impoverished British economy, but he had failed to recognize that artistic taste and the botanical sciences were changing. Moreover, his audience had judged him incapable of fulfilling his exaggerated promises.[15]

Thornton's work attracted vehement criticism during his lifetime. One reviewer wrote: 'Dr Thornton is proceeding in his great national work, as he pompously calls it . . . Seventeen numbers are already before the public, whose expectations, it is believed, are egregiously disappointed. The work was evidently not intended for common readers: it is dressed out for the levee and the drawing-room of princes and nobility.'[16] Another emphasized that

> the patience of the public must soon be exhausted. As to ourselves, we have not a drop left. Never were lavish promises more scantly realized . . . His work is, indeed, little more than a piece 'of shreds and patches', clumsily stitched together with coarse packthread, and instead of a national honour, may justly be deemed a national disgrace.[17]

With hindsight, the *Temple* is a work of neither science nor education: it was simply showmanship. Thornton's idiosyncratic choice of plants failed to represent Linnaeus's system, 'which ought now [early nineteenth century] to find no other place in science, than among the records of things whose fame has passed away'.[18] Thornton's placement of plants within landscapes, sometimes interpreted as an attempt to represent species' ecology, echoing concepts being developed by Alexander von Humboldt, was more realistically designed to evoke specific emotions in the viewer towards the

plants portrayed – feelings that are reflected in the florid, meandering text.[19] Consequently, the plates fall short of objectivity and the high standards of natural-history illustration during the early nineteenth century, a period populated by many exceptional botanical artists.[20] The *Temple* also failed to teach Linnaean botany. Not only were important parts of the flowers obscured, but the publication could not attract a wide audience, since its price was beyond the pockets of both student and teacher.[21]

The *Temple* is a peculiar cul-de-sac in Enlightenment botany. However, despite its vapid text, the plates captured the public imagination in the mid-twentieth century, and today individual original plates attract extravagant prices at auction.[22] The comments by one reviewer about the original work were prophetic: 'the plates are finished with exquisite delicacy, and will immortalize the vanity and insufficiency of Dr Thornton.'[23]

Looking without seeing

Thornton's work, albeit seen by few people, shows an author and illustrators using botanical imagery to convey manipulative messages. However, it is the illustrator's ability to see and accurately record, in an unbiased way, what is observed that is the hallmark of the use of botanical illustration in education. Like sceptical scientists, the wider public drawn into a subject by images must be convinced that illustrators are reliable witnesses and that their illustrations are accurate. When William Burchell published the account of his journeys in southern Africa in the early nineteenth century, he was at pains to emphasize that 'neither have the drawings been touched by any other hand . . . in order to ensure greater correctness in the vignettes, the author has made all these drawings upon the [wood] blocks themselves . . . Those who can appreciate the art, will not fail to admire the care and abilities of the engraver.'[24] Émile Deyrolle, grandson of the founder of Deyrolle, the Parisian natural-history dealership, made the point succinctly: 'education using the eyes is least tiring to the mind, but can have good results only if the ideas engraved in the mind of the child are rigorously accurate.'[25] Moreover, learning to see, rather than being beguiled by glamour, must be encouraged among the viewers of botanical illustrations.

Virginian witch hazel from Charles Sprague Sargent's *The Silva of North America* (1893). A sprig of flowers, which appear before the leaves, together with the previous year's fruit, is shown against the background of a leafy shoot. Arranged around this are dissected and magnified details of the flowers and fruit, and a diagrammatic section showing the relative arrangement of the floral parts. Black-and-white engraving made by Philibert and Eugène Picart, supervised by the French illustrator Alfred Riocreux in Paris, based on pencil drawings by the American botanical illustrator Charles Edward Faxon.

When training and teaching the eye to see, the nineteenth-century British botanist and popularizer of science Phoebe Lankester emphasized the benefits of prolonged, dedicated application: 'the naturalist – he who has thought and worked amongst the wonderful and curious things of this beautiful world, has his eyes sharped and educated to observe; by constant habit, he sees at a glance the arrangement of the parts of a flower.'[26] Botanical educators before and since have recapitulated the substance of Deyrolle's and Lankester's views: drawing creates 'clear and sharp conceptions' that erase 'loose, hazy, or dim ideas'.[27]

Between 1771 and 1774 Rousseau wrote a series of botanical letters to his cousin Madeleine-Catherine Delessert and her daughter, Madelon.[28] He emphasized that before students were taught 'to name what they see [according to Linnaean principles], let us begin by teaching them how to see'.[29] Early in his 36-year career as professor of botany at Smith College, a liberal arts college for women in Massachusetts, the Canadian biologist William Francis Ganong argued that

> [the] ability to draw . . . is an important element in a student's scientific education. To realize, however, the full value of drawing, it is necessary that this shall consist not in the making of pictures correct in perspective and fine in finish, but in diagrammatic drawings that convey to the mind of the beholder accurate conceptions of the real construction of the object represented.[30]

Moreover, he said, 'the very act of drawing will call attention to features otherwise overlooked.'[31] Ganong articulated a concern that is familiar to teachers: 'a clever student may by verbal answers alone convey the impression that he has seen an object fully.'[32]

For their first lesson, Ganong recommended that students be forced into the science of seeing by being 'given a fair object, and told to first

study and then draw it without help', to which 'most students . . . answer in despair that they cannot draw'.[33] Reluctantly, he conceded that 'a drawing copied from a good source is a better record . . . than no drawing at all.'[34] One of Ganong's recommendations as a source of models were the black-and-white illustrations in Charles Sprague Sargent's folio-sized, fourteen-volume *The Silva of North America* (1891–1902). The technical skill of the illustrator, Charles Edward Faxon, and of the engravers means that each aesthetically pleasing, naturalistic portrait captures the 'feel' of the plant in life. Moreover, as one looks at these images ever more carefully, layers of detail are revealed. Comparison with living or preserved samples reveals similar details, demonstrating the successful collaboration of artist, engraver and author.

Richweed, a member of the mint family, from Linnaeus's *Hortus Cliffortianus* (1737). Black-and-white engraving made by the Dutch engraver Jan Wandelaar, based on an illustration by Georg Dionysius Ehret, laid out according to Linnaeus's precept that 'all parts should be recorded in their natural position and size, including the most minute parts of the fruit-body.'[38]

Words and Pictures

Linnaeus laid out his botanical precepts in *Philosophia botanica* (1751), asserting that classification and nomenclature were the foundations of botany – 'anyone who knows this is a botanist, and no one else is' – setting the tone for academic botany long after his classification system was consigned to history.[35] Surveying the quantity of historical illustrations reproduced today, one gets an impression that botany was about the study of images. Yet a more uncertain conclusion is reached when botanical books of the period are studied; images reveal their double-edged qualities. Images may attract attention but may also alienate because of their perceived association with lack of rigour and objectivity.[36]

Linnaeus's relationship with the botanical image reflects such ambivalence. He particularly admired the work of the German botanical illustrator Georg Dionysius Ehret. Ehret was in his thirties when he illustrated Linnaeus's *Hortus Cliffortianus* (1737), a description of plants growing at the Hartecamp estate of George Clifford, an Amsterdam banker and governor of the Dutch East India Company. Linnaeus wanted botanists to learn species' typical features, rather than those obscured by natural variation or artificially selected.[37] Consequently, in this so-called typological approach, he argued that highly technical language was best to

describe typical features, and that ruler and pencil were to be used only with caution.[39]

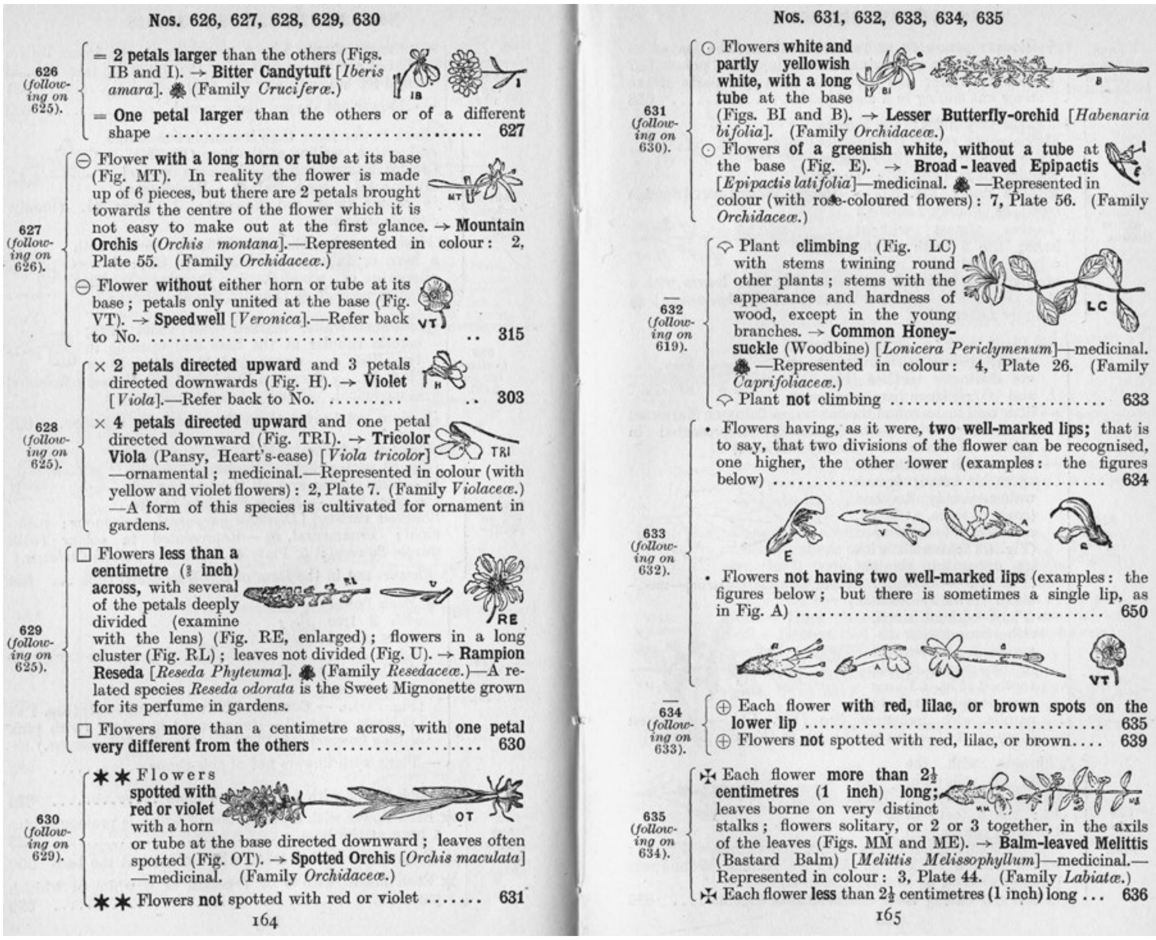
In her introduction to *Botany for Ladies* (1842), the English horticultural and botanical writer Jane Wells Webb Loudon reprised the familiar complaint about learning Linnaean botany:

> With the exception of Dr [John] Lindley's Ladies' Botany,[40] they were all sealed books to me; and even that did not tell half I wanted to know, though it contained a great deal I could not understand. It is so difficult for men whose knowledge has grown with their growth, and strengthened with their strength, to imagine the state of profound ignorance in which a beginner is, that even their elementary books are like the old Eton Grammar when it was written in Latin – they require a master to explain them.[41]

Loudon's book was illustrated with hand-coloured metal engravings by William Watts, based on drawings by Sarah Anne Drake, who worked extensively with John Lindley. Ironically, Lindley has been identified as one of the men who redefined the intellectual focus of early nineteenth-century botany specifically to exclude women.[42]

Introducing his translation of Rousseau's botanical letters in the late eighteenth century, Thomas Martyn emphasized the value of images as

Scarlet geranium, a South African species first cultivated in the garden of the Bishop of London, Henry Compton, in 1714.[43] The plate, a line engraving, etching and mezzotint from John Martyn's *Historia plantarum rariorum* (1728), is one of the earliest English examples of colour printing from a single metal plate.[44] It was made by the English engraver Elisha Kirkall, based on an illustration by the Dutch botanical illustrator Jacob van Huysum, and was sponsored by William Sherard, a patron of early eighteenth-century botany.



Nos. 626, 627, 628, 629, 630

626 (*following on* 625).
= **2 petals larger** than the others (Figs. IB and I). → **Bitter Candytuft** [*Iberis amara*]. (Family *Cruciferæ*.)
= **One petal larger** than the others or of a different shape 627

627 (*following on* 626).
⊖ Flower **with a long horn or tube** at its base (Fig. MT). In reality the flower is made up of 6 pieces, but there are 2 petals brought towards the centre of the flower which it is not easy to make out at the first glance. → **Mountain Orchis** (*Orchis montana*].—Represented in colour: 2, Plate 55. (Family *Orchidaceæ*.)
⊖ Flower **without** either horn or tube at its base; petals only united at the base (Fig. VT). → **Speedwell** [*Veronica*].—Refer back to No. 315

628 (*following on* 625).
× **2 petals directed upward** and 3 petals directed downwards (Fig. H). → **Violet** [*Viola*].—Refer back to No. 303
× **4 petals directed upward** and one petal directed downward (Fig. TRI). → **Tricolor Viola** (Pansy, Heart's-ease) [*Viola tricolor*]—ornamental; medicinal.—Represented in colour (with yellow and violet flowers): 2, Plate 7. (Family *Violaceæ*.)—A form of this species is cultivated for ornament in gardens.

629 (*following on* 625).
□ Flowers **less than a centimetre** ($\frac{2}{5}$ **inch**) **across,** with several of the petals deeply divided (examine with the lens) (Fig. RE, enlarged); flowers in a long cluster (Fig. RL); leaves not divided (Fig. U). → **Rampion Reseda** [*Reseda Phyteuma*]. (Family *Resedaceæ*.)—A related species *Reseda odorata* is the Sweet Mignonette grown for its perfume in gardens.
□ Flowers **more** than a centimetre across, with **one petal very different from the others** 630

630 (*following on* 629).
✱✱ Flowers **spotted with red or violet** with a horn or tube at the base directed downward; leaves often spotted (Fig. OT). → **Spotted Orchis** [*Orchis maculata*]—medicinal. (Family *Orchidaceæ*.)
✱✱ Flowers **not** spotted with red or violet 631

164

Nos. 631, 632, 633, 634, 635

631 (*following on* 630).
⊙ Flowers **white and partly yellowish white, with a long tube** at the base (Figs. BI and B). → **Lesser Butterfly-orchid** [*Habenaria bifolia*]. (Family *Orchidaceæ*.)
⊙ Flowers **of a greenish white, without a tube** at the base (Fig. E). → **Broad-leaved Epipactis** [*Epipactis latifolia*]—medicinal. —Represented in colour (with rose-coloured flowers): 7, Plate 56. (Family *Orchidaceæ*.)

632 (*following on* 619).
Plant **climbing** (Fig. LC) with stems twining round other plants; stems with the appearance and hardness of wood, except in the young branches. → **Common Honeysuckle** (Woodbine) [*Lonicera Periclymenum*]—medicinal. —Represented in colour: 4, Plate 26. (Family *Caprifoliaceæ*.)
Plant **not** climbing 633

633 (*following on* 632).
• Flowers having, as it were, **two well-marked lips;** that is to say, that two divisions of the flower can be recognised, one higher, the other lower (examples: the figures below) 634
• Flowers **not having two well-marked lips** (examples: the figures below; but there is sometimes a single lip, as in Fig. A) 650

634 (*following on* 633).
⊕ Each flower **with red, lilac, or brown spots on the lower lip** 635
⊕ Flowers **not** spotted with red, lilac, or brown.... 639

635 (*following on* 634).
✠ Each flower **more than** $2\frac{1}{2}$ **centimetres (1 inch) long;** leaves borne on very distinct stalks; flowers solitary, or 2 or 3 together, in the axils of the leaves (Figs. MM and ME). → **Balm-leaved Melittis** (Bastard Balm) [*Melittis Melissophyllum*]—medicinal.—Represented in colour: 3, Plate 44. (Family *Labiatæ*.)
✠ Each flower **less** than $2\frac{1}{2}$ centimetres (1 inch) long ... 636

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teaching aids, when faced with lengthy, botanical language: 'good plates, or figures of plants, will also be of considerable assistance … there is indeed no want of such help: but the misfortune is, that these books are so very expensive, as to be far beyond the purse of all but the opulent.'[45]

The list of Martyn's works for the 'opulent' reads like the catalogue of an exclusive botanical library: among them Basil Besler's *Hortus Eystettenis* (1613), Thomas's father, John Martyn's *Historia plantarum rariorum* (1728–37), Mark Catesby's *Natural History of Carolina, Florida and the Bahama Islands* (1729–47), Elizabeth Blackwell's *A Curious Herbal* (1737–9),[46] Ehret's *Plantae et papiliones rariores* (1748–59), Georg Oeder's *Flora Danica* (1761–1883) and Nikolaus Joseph von Jacquin's *Flora Austriacae* (1773–8). As second best, 'for the sake of such as do not possess the more splendid works, and live remote from public libraries', Martyn recommended illustrations

Gaston Bonnier's *Name This Flower* (1917), an identification guide to European plants, used simple black-and-white sketches to clarify descriptive text (above). These complement reproductions of coloured drawings (opposite) of common species that are likely to be found by botanical beginners.

Plate 56.

ORCHIDACEÆ

(*Continued*).

1. **Spider Orchid** [*Ophrys sphegodes*].

2. **Drone Orchid** (Late Spider Orchid). — [*Ophrys fuciflora*].

3. **Bee Orchid** [*Ophrys apifera*].

4. **Fly Orchid** [*Ophrys muscifera*].

5. **Egg-shaped Listera** (Twayblade). — *Listera ovata*].

6. **Bird's-nest Neottia.** — *Neottia Nidus-avis.*

7. **Broad-leaved Epipactis** [*Epipactis latifolia*] — medicinal.

Plate 57.

NAIADACEÆ.

1. **Floating Pondweed** [*Potamogeton natans*]. —

ARACEÆ.

2. **Spotted Arum** (Lords-and-ladies, Cuckoo-pint). — [*Arum maculatum*]. — medicinal. Leaves and flowers. 2 *bis*, Fruits.

TYPHACEÆ.

3. **Broad-leaved Reed-mace** (Bulrush). — [*Typha latifolia*].

JUNCACEÆ.

4. **Spreading Rush** (Rush). — [*Juncus effusus*]. — industrial.

5. **Field Wood-rush** (Chimney-sweeps, Good Friday Grass).—[*Luzula campestris*].

in John Gerard's *The Herball* (1633) and Robert Morison's *Plantarum historiae universalis oxoniensis* (1680, 1699).[47] Yet, in *The Language of Botany* (1793), a glossary of botanical terminology aimed at students and formally trained botanists, Martyn included no images to aid his audience.[48] More than half a century later another professor of botany at the University of Cambridge, John Stevens Henslow, mentor of Charles Darwin and a man with a reputed fondness for the 'hard words used in botany', wrote *A Dictionary of Botanical Terms* (1857), with – as its title page proclaimed – 'nearly two hundred [wood]cuts' that, 'although small . . . [were] usually quite sufficient to convey the requisite information', for illustrating the definitions of more than 3,000 terms.[49]

Gaston Eugène Marie Bonnier, professor of botany at the Sorbonne in Paris and author of the twelve-volume *Flore complète illustrée en couleurs de France, Suisse et Belgique* (Complete Colour Flora of France, Switzerland and Belgium, 1911–34), concurred with Bersot's criticism of those who believed the study of plants required detailed, formal botanical education – often the same botanists who decried the use of images in elementary botanical texts. Bonnier published a method of identifying French plants with '5,289 Figures representing the characters of all the species, described without technical words'.[50] That is, he capitalized on synergies that exist between text and images.

Mid-nineteenth century botanical teaching in much of Europe has been caricatured as little more than the study of classification focused on typical flowers. However, in Germany, a new botany emerged wherein students were given the tools and knowledge to study any plant, from algae through mosses and ferns to conifers and flowering plants, and even fungi. The teaching did not focus on classification, but encompassed comparative anatomy, morphology and physiology, and students were encouraged to look and discover for themselves rather than accepting assertions from their teachers. The British botanist Sydney Howard Vines's translation of key German textbooks introduced English readers to these novel teaching approaches. Vines and Frederick Orpen Bower's *A Course of Practical Instruction in Botany* (1885–7) became a popular textbook: 'produced intentionally without the support of detailed illustrations; for these are apt to blunt the keenness of search, by substituting the observations of others for the personal experience of finding out for oneself'.[51]

Making botany popular

As Victorian Britain asserted itself on the world stage, becoming the foremost commercial, industrial and imperial power, leadership of its scientific culture was being wrested by younger men from ageing, Oxbridge-trained gentlemen of science. Many of these men were educated outside traditional universities, and styled themselves evolutionary naturalists.[52] Moreover, science became fashionable among the growing urbanized, middle and working classes, who had the leisure, wealth and literacy, denied to their parents and grandparents, for such pursuits. The Great Exhibition of the Works of Industry of All Nations in 1851 created and fed enthusiasm for scientific knowledge.[53] Diverse organizations, including working men's and religious organizations and natural-history societies, and people, such as the clergy, so-called science popularizers and even some evolutionary naturalists, contributed to satisfying this new hunger.[54] Such botanical knowledge could, Martyn wrote, 'be of use to such of my fair countrywomen and unlearned countrymen as wished to amuse themselves with natural history', but people educated in this manner were discouraged from trespassing on the activities of the professional.[55]

Women made a major contribution to the popularization of botany through writing and illustrating accessible books about plants.[56] The English botanical illustrator Elizabeth Twining, philanthropic heiress to the Twining tea fortune, illustrated the two-volume, royal-folio *Illustrations of the Natural Orders of Plants with Groups and Descriptions* (1849–55) with 160 hand-coloured lithographs. She 'hoped these illustrations, combined with descriptions, in simple, and as far as possible untechnical language, may add something to the enjoyment to be derived from plants'.[57] Twining wrote within a tradition of 'examin[ing] the glorious works of an Almighty Creator . . . [to] perceive their excellent beauty and endless variety'.[58] Her clear intention to popularize botany did not patronize her readers, either in word or illustration. Colourful, densely arranged bouquets of flowers, supported with black-and-white dissections of plant parts, were complemented with detailed, informative text. The models for Twining's plates probably came from gardens around London, including Kew. However, her bouquets of plants, which flower at different times of the year and come from different areas of the globe, are biological impossibilities. The

Aristolochiaceæ

The Aristolochia Tribe.

expensive folio had a limited circulation, but was reprinted in 1868, in quarto, with cheaply coloured plates.

An important aspect of popularization is giving people high-quality, low-cost tools to identify for themselves the plants they find.[59] Ideally, a popular guide to the plants of an area should illustrate all relevant species in colour, so that they can be identified with confidence. Moreover, the guide should be a single, concise volume with a price low enough that it will not dissuade even the casually interested from purchasing it.

In 1858 the British botanist George Bentham published the first edition of his *Handbook of the British Flora*. It would go into seven editions and numerous reprints to become the standard, if controversial, Flora for the British Isles. Its position was usurped only in 1952, when Arthur Clapham, Thomas Tutin and Edmund Warburg's *Flora of the British Isles*, affectionately known as 'CTW', was published.[60] The first edition of Bentham's *Handbook*, although densely printed and unillustrated, was a better work of introductory scientific botany than anything that had gone before. Through its long history, the assertion in the first edition that 'the aptness of a botanical description like the beauty of a work of imagination, will always vary with the style and genius of the author' was maintained.[61] Circumstances, including Walter Hood Fitch's black-and-white line illustrations of species in the two-volume second edition (1863–5), contributed to the nearly century-long success of Bentham's *Handbook* among serious amateur botanists. Between 1957 and 1965, four volumes of small black-and-white line drawings by Sybil Roles were published to complement 'CTW', with readers referred to the black-and-white lithographed line drawings in Stella Ross-Craig's eight-volume *Drawings of British Plants* (1948–74) for additional detail.[62] When the first volume of Ross-Craig's illustrations was published, Edward James Salisbury, director of the Royal Botanic Gardens, Kew, emphasized that the challenge for the illustrator was 'to convey what may be termed the individuality of the species, which is too often lost in drawings that are merely accurate in scientific detail'.[63]

Peter Sell and Gina Murrell's five-volume *Flora of Great Britain and Ireland* (1996–2018), the standard Flora of early twenty-first-century Britain, emphasizes that a good botanical description makes 'a picture of the plant unfold before you as you read it and includes as much of the variation as possible'.[64] In these volumes, black-and-white line illustrations

A collection of species illustrating the diversity of the birthwort family: 1. European birthwort; 2. Dutchman's pipe; 3. pelican flower; 4. asarabacca; 5. birthwort capsule; and 6. wood of Southeast Asian *Thottea tomentosa*. Hand-coloured lithograph based on original illustrations by Elizabeth Twining and published in her *Illustrations of the Natural Orders of Plants* (1868).

are used sparsely and strategically to demonstrate comparative details that are difficult to clarify with text, rather than attempting to illustrate every species in Great Britain and Ireland.

The earlier works were expensive and required a high level of familiarity with botany; in them (with the exception of Ross-Craig's work), black-and-white illustrations were secondary to the text or had specific purposes to clarify the text. This changed in 1965 with the publication of William Keble Martin's *The Concise British Flora in Colour*. Keble Martin, a clergyman, had travelled across Britain sketching and painting plants since late 1899.[65] By the time *The Concise British Flora* was published, he had made more than 1,400 watercolours. The story behind the making of the high-quality illustrations by a venerable author and a publisher willing to risk a modestly priced, high-quality colour publication produced a publishing sensation. By 1980 more than 1.5 million copies had been sold.[66] Today, booksellers' shelves are weighed down with illustrated (often photographic) guides to the plants of Britain (and elsewhere), yet few have repeated either the sensation or the usefulness of Keble Martin's *Flora*.

Botanical wallcharts

By the end of the nineteenth century a strong body of opinion had developed that viewed traditional botany as necessary only as a foundation upon which to investigate ideas of Darwinian evolution, to use developments in physics and chemistry to probe the internal structures and workings of cells, and to fulfil the scientific demands of medicine, agriculture and industry.[67] Traditional botany became part of a pejorative concept of 'natural history', an activity best suited to organizations outside universities, such as museums, botanic gardens and perhaps learned societies.

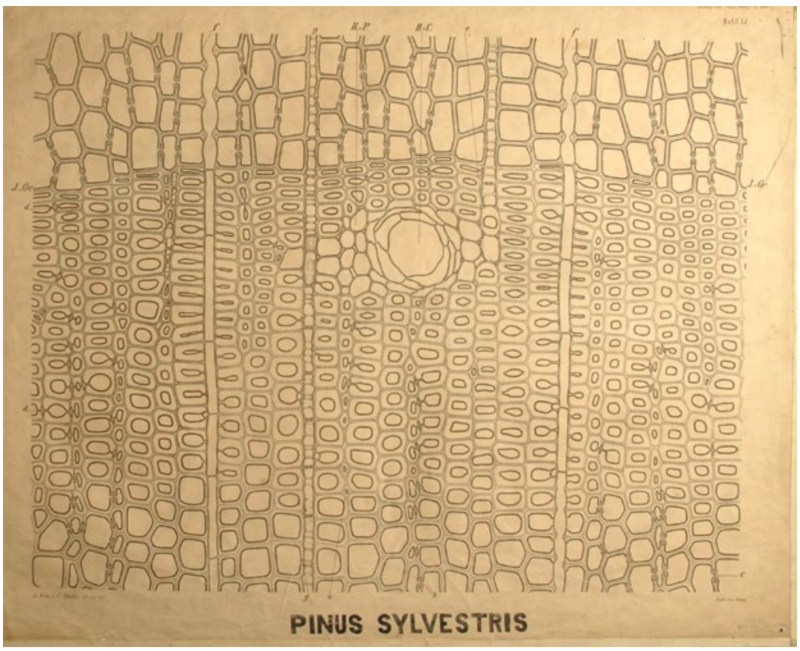
Since the earliest times, living plants – in the wild and in gardens – have been visual aids, to complement words, in teaching and learning about plants.[68] As students synthesize complex, technical information invisible to the unaided eye, living plants are complemented with preserved specimens and botanical illustrations.[69] In some cases, these illustrations are ephemeral, for example a teacher drawing in chalk on a blackboard or in coloured pens on overhead projector film, or a demonstrator making a sketch on a scrap of paper in a practical class.[70] Visual aids are not therefore primarily

objects to admire – beauty is a bonus – they are functional, practical means to develop students' skills at observing and interpreting natural objects.[71]

Between 1820 and 1841 William Jackson Hooker (later director of Kew) was professor of botany at Glasgow University. He soon learned that to supplement his meagre academic salary he had to attract students to his lectures. In part, he did this by using his artistic skill to create wallcharts that could be seen readily by all students in a lecture hall, thereby setting a bar for botanical education across British universities.[72]

Functionality and beauty were combined when the technology for the reproduction of large chromolithographs facilitated the commercial production of wallcharts. These charts, a collaboration between illustrations, researchers and manufacturers, filled a demand for high-quality botanical teaching aids.[73] Moreover, their manufacturers argued that 'True-to-life, scientifically reliable wallcharts can replace natural objects themselves in class lessons; they teach more than the spoken word.'[74]

In 1857 John Henslow issued a series of nine wallcharts under the title *Prof. Henslow's Botanical Diagrams, designed to be used as aids for the teaching of fundamental botany in schools.*[75] These were lithographed by Walter Fitch, based on drawings by Henslow and his daughter Anne Henslow Barnard, who went on to become a notable botanical illustrator in her own



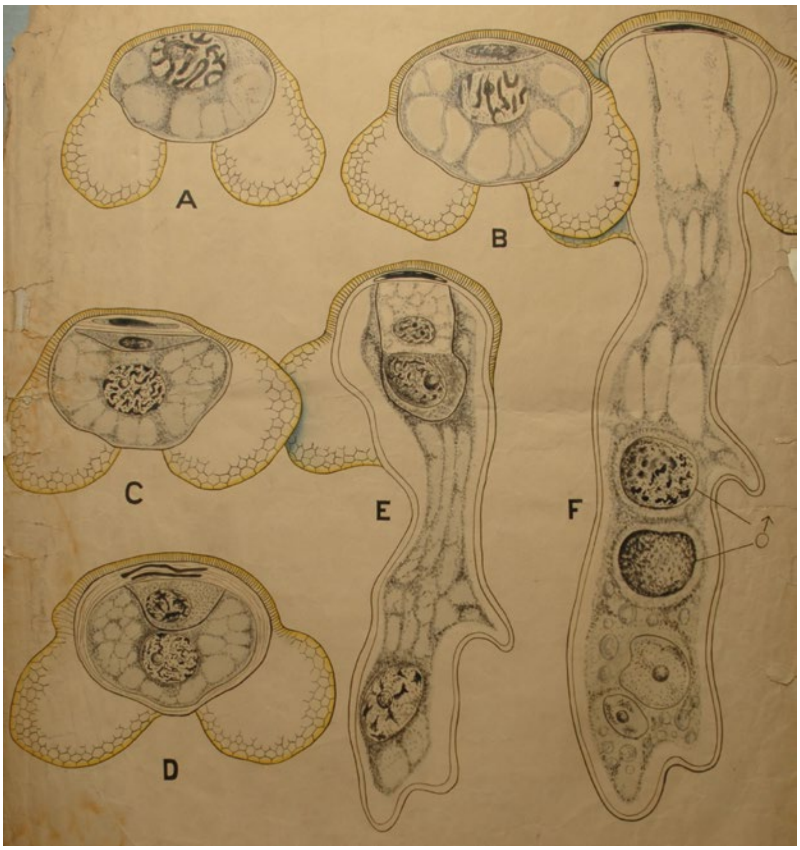
Leopold Kny's wallchart of a magnified transverse section of a piece of Scots pine at the junction of two annual rings. Lithograph by Von Laue, based on drawings by Kny and C. Müller and published in Berlin as part of the *Botanische Wandtafeln* series in the late 1800s.

XXX.
Dodel-Port, Atlas.
Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
Arn. & Carol. Dodel-Port ad nat del.
Cuscuta glomerata, Choisy.
J. E. Schreiber, Esslingen, impr.

Arnold and Carolina Dodel-Port's wallchart of the North American parasite rope dodder, showing details of the plant's anatomical associations with its host, together with magnifications of the flowers and fruit. Chromolithograph based on drawings made by the Dodarts from nature and published by J. F. Schreiber in Esslingen, Germany, as part of the *Anatomisch physiologische Atlas der Botanik* series in the late 1800s.

right. In Edinburgh, as professor of botany at the university and Regius Keeper of the Royal Botanic Garden, Isaac Bayley Balfour transformed the teaching of botany in Scotland through his skilful use of visual aids.[76]

By the end of the century commercially successful sets of botanical wallcharts were being issued in continental Europe, together with explanatory books of teaching notes.[77] One of the most prominent of these was the 120-chart series (*Botanische Wandtafeln*; Botanical Wallcharts) on anatomy, morphology and systematics, issued under the name of the German botanist Carl Ignaz Leopold Kny between 1874 and 1911.[78] Illustrators included Kny himself, the botanist and mycologist Louis René Étienne Tulasne, the illustrator Alfred Riocreux, the botanist Jean-Baptiste Édouard Bornet and the botanist and mycologist Heinrich Anton de Bary. Between 1878 and 1893 the Swiss botanist Arnold Dodel-Port and his wife, Carolina, issued a series of 42 charts entitled *Anatomisch physiologische Atlas der Botanik* (Anatomical and Physiological Atlas of Botany), based on their



Bespoke wallchart showing the sequence of cell division associated with the germination of a magnified pollen grain of Corsican pine, made for the department of botany at the University of Oxford in the early twentieth century. Pen-and-ink drawing with grey wash and hand-colouring on paper by an unknown artist.

own illustrations. The plants presented on these wallcharts were selected in consultation with the men driving botanical teaching and research in Europe. Consequently, the same wallchart could be used to teach botany at all levels, from school through to university; teachers and students could extract and interpret the information that was sufficient to their specific purposes.

Where commercial wallcharts were insufficient, institutions could produce bespoke charts, using illustrations copied from published works or original materials. The specialized nature of such charts may have limited their longevity, however. Audiences for these charts will have been small and the subjects may have changed rapidly in response to the results of research. In contrast, commercial charts illustrated fundamental botanical facts.

More than a century after these commercial wallcharts were made, their accuracy and the attention to detail of the illustrators and lithographers mean that they are still valuable aids for teaching about gross morphological features and plant anatomy. Moreover, their layout – designed to hold the students' attention – gives them special aesthetic appeal. Those charts that have survived to the present day, unlike Thornton's illustrations in *Temple of Flora*, succeed as teaching aids that happen to be beautiful.

Three-dimensional botanical models

Botanical illustrators convert three-dimensional plants into two-dimensional images, which – with the skilful use of shade, perspective and, perhaps, 'taste' – become three-dimensional illusions. Large, illustrated wall posters have proved to be effective tools for teaching large audiences about tiny, frequently microscopic, structures. However, the challenge for researchers, students and teachers is to understand the arrangement of three-dimensional-structures – that is, how plant parts are arranged relative to one another in space.

In the late nineteenth century models 'intended to illustrate lectures . . . regardless of the seasons' provided a didactic solution to the problem: 'as the models are made on a more-or-less enlarged scale, they facilitate the recognition of all the fine and even smallest organs, and the comprehension of the distinguishing characteristics of the structure of flowers by comparison with living plants; besides, many can be taken to pieces, and

are represented in sections.'[79] Moreover, three-dimensional models gave teachers and students the opportunity to explore botanical structures from several angles, not just those chosen by illustrators (which may have as much to do with aesthetic design as scientific purpose).

The bespoke glass sculptures made to complement the American botanist George Lincoln Goodale's teaching at Harvard University constitute perhaps the world's most celebrated collection of three-dimensional botanical educational models. Between 1886 and 1936 more than 4,300 lifelike models, each of which 'tells the same story of nature closely followed', were made by the Bohemian father-and-son glass artists Leopold and Rudolf Blaschka.[80] In contrast, in the late nineteenth and early twentieth century mass-produced models, such as those made by Maison Auzoux, the Brendel Company and Maison Émile Deyrolle, were purchased by institutions to become part of botanical teaching programmes across Europe, the Americas, Australia and New Zealand.[81]

The French physician and naturalist Louis Thomas Jérôme Auzoux established his model factory, Maison Auzoux, at Saint-Aubin-d'Écrosville to manufacture '*anatomie clastique*' (anatomical models that could be split into pieces).[82] The Brendel Company was founded in Breslau (now Wrocław, Poland) by Robert Brendel in 1866. On Brendel's death, his company was taken over by his son Reinhold and its workshops moved near to Berlin.[83] These robust, hard-wearing models were made by expert artisans using materials they had at hand, such as papier-mâché, wood, plaster, gelatin, rattan, wire and gutta-percha, before being painted, assembled, varnished and lacquered by hand. Moreover, the artisans collaborated with botanists, ensuring that a wide range of botanically accurate models were available, often accompanied by detailed teaching notes. Hundreds of different sorts of model were offered for sale by agents in the Americas and Europe.[84]

Only a fraction of the thousands of botanical wallcharts and models sold before the Second World War survive. Some of these teaching aids, often marked with the evidence of the generations who were taught using them, have outlasted the people who considered them anachronisms of the past or who discovered other visual means to explain the structure of plants to their students.

MODERN TECHNOLOGY, PHILANTHROPY and the enthusiasm of those charged with the stewardship of collections have handed centuries of data summarized in botanical illustrations to any who wish to view them. This legacy complements hundreds of millions of plant images, mostly digital photographs, made during the last fifty years. However, if illustrations and photographs are to maintain scientific value, they must be buffered against technological change, degradation and the loss of associated metadata, which may render hard-won images merely decorative.

Images are essential in today's plant sciences, albeit not in the same way as they were five centuries ago. As the focus of botany has broadened, so has the range of illustration and reproduction techniques. Whether one is a botanical illustrator working with graphite or watercolour, or a scientific photographer painting with pixels, one is faced with similar questions: editing nature; relationships among data, information and knowledge; and the ethics of evidence and trust.

Education encourages one to see. Illustration forces one to observe and record, to interpret the unfamiliar in terms of the familiar. However, we must learn to read illustrations if they are to serve the objective research and educational purposes of both creator and viewer. Knowledge derived from illustrations may challenge accepted ideas, stretching the imagination. Illustrations disperse practical information about the cultivation, harvest and use of plants. Moreover, evidence supporting essential botanical ideas, which are fundamental for the solution of today's global problems, may be effectively presented in illustrations.

Three-dimensional models by the Brendel Company of autumn crocus flower and root, and cypress spurge inflorescence. Late nineteenth-century papier-mâché and hand-painted models, which can be separated into parts to reveal the internal structure.

APPENDIX: PLANT NAMES

Aloe, Socotran	*Aloe perryi* (Asphodelaceae)
Apple	*Malus* spp. (Rosaceae)
Apple, Central Asian wild	*Malus sieversii* (Rosaceae)
Archangel, yellow	*Lamiastrum galeobdolon* (Lamiaceae)
Asarabacca	*Asarum europaeum* (Aristolochiaceae)
Aster, China	*Callistephus chinensis* (Asteraceae)
Banana	*Musa* spp. (Musaceae)
Baobab	*Adansonia digitata* (Malvaceae)
Barricuda	*Cavanillesia arborea* (Malvaceae)
Birch, paper	*Betula papyrifera* (Betulaceae)
Bird-of-paradise plant	*Strelitzia reginae* (Strelitziaceae)
Birthwort	*Aristolochia* spp. (Aristolochiaceae)
Birthwort, European	*Aristolochia clematitis* (Aristolochiaceae)
Blackcurrant	*Ribes nigrum* (Grossulariaceae)
Bogbean	*Menyanthes trifoliata* (Menyanthaceae)
Box	*Buxus sempervirens* (Buxaceae)
Brasil	*Paubrasilia echinata* (Fabaceae)
Brazil nut	*Bertholletia excelsa* (Lecythidaceae)
Broccoli	*Brassica oleracea* (Brassicaceae)
Brussels sprout	*Brassica oleracea* (Brassicaceae)
Bryony, black	*Dioscorea communis* (Dioscoreaceae)
Buddha's hand	*Citrus medica* var. *sarcodactylis* (Rutaceae)
Buddleia	*Buddleja* spp. (Scrophulariaceae)
Buttercup	*Ranunculus* spp. (Ranunculaceae)
Butterfly bush	*Buddleja davidii* (Scrophulariaceae)
Cabbage	*Brassica oleracea* (Brassicaceae)
Camellia	*Camellia japonica* (Theaceae)
Canary grass	*Phalaris canariensis* (Poaceae)
Cashew	*Anacardium occidentale* (Anacardiaceae)
Cattleya	*Cattleya* spp. (Orchidaceae)
Cauliflower	*Brassica oleracea* (Brassicaceae)
Cherry	*Prunus* subgenus *Cerasus* (Rosaceae)
Chilli	*Capsicum* spp. (Solanaceae)
Christmas cactus	*Schlumbergera × buckleyi* (Asteraceae)
Chrysanthemum	*Chrysanthemum* (Asteraceae)
Chrysanthemum, annual	*Ismelia carinata* (Asteraceae)
Clary, meadow	*Salvia pratensis* (Lamiaceae)
Clove	*Syzygium aromaticum* (Myrtaceae)
Cochineal cactus	*Opuntia cochenillifera* (Cactaceae)

Cock's-foot	*Dactylis glomerata* (Poaceae)
Coco de mer	*Lodoicea maldivica* (Arecaceae)
Cocoa	*Theobroma cacao* (Malvaceae)
Coffee	*Coffea arabica* (Rubiaceae)
Coltsfoot	*Tussilago farfara* (Asteraceae)
Corncockle	*Agrostemma githago* (Caryophyllaceae)
Corpse flower	*Rafflesia arnoldii* (Rafflesiaceae)
Cotoneaster	*Cotoneaster* spp. (Rosaceae)
Cranberry, bog	*Vaccinium oxycoccus* (Ericaceae)
Crocus, autumn	*Colchicum autumnale* (Colchicaceae)
Crowfoot	*Ranunculus* subgenus *Batrachium* (Ranunculaceae)
Crowfoot, common water	*Ranunculus aquatilis* (Ranunculaceae)
Cucumber, wild	*Ecballium elaterium* (Cucurbitaceae)
Dahlia	*Dahlia* spp. (Asteraceae)
Daisy, common	*Bellis perennis* (Asteraceae)
Dandelion	*Taraxacum* (Asteraceae)
Dead nettle, white	*Lamium album* (Lamiaceae)
Dodder, rope	*Cuscuta glomerata* (Orobanchaceae)
Dog's-tooth violet	*Erythronium dens-canis* (Liliaceae)
Dogsbane	*Apocynum* spp. (Apocynaceae)
Dragon tree	*Dracaena draco* (Asparagaceae)
Dragon's-blood tree, Socotran	*Dracaena cinnabari* (Asparagaceae)
Dutchman's pipe	*Aristolochia sipho* (Aristolochiaceae)
Elm	*Ulmus* spp. (Ulmaceae)
Ergot	*Claviceps purpurea* (Clavicipitaceae)
Eucalyptus	*Eucalyptus* spp. (Myrtaceae)
Evening primrose	*Oenothera* spp. (Onagraceae)
Fan palm, European	*Chamaerops humilis* (Arecaceae)
Fan palm, Nubian	*Medemia argun* (Arecaceae)
Fever tree	*Cinchona* spp. (Rubiaceae)
Fig	*Ficus* spp. (Moraceae)
Fir	*Abies* spp. (Pinaceae)
Flame lily	*Gloriosa superba* (Colchicaceae)
Forsythia	*Forsythia* spp. (Oleaceae)
Forsythia, green-stemmed	*Forsythia viridissima* (Oleaceae)
Frankincense	*Boswellia* spp. (Burseraceae)
Fustic	*Chlorophora tinctoria* (Moraceae)
Gamboge	*Garcinia* spp. (Clusiaceae)
Geranium, scarlet	*Pelargonium inquinans* (Geraniaceae)
Goatgrass, barbed	*Aegilops triuncialis* (Poaceae)
Gooseberry	*Ribes uva-crispa* (Grossulariaceae)
Grape, European	*Vitis vinifera* (Vitaceae)
Grape phylloxera	*Daktulosphaira vitifoliae* (Phylloxidae; Hemiptera)
Ground ivy	*Glechoma hederacea* (Lamiaceae)
Groundsel	*Senecio vulgaris* (Asteraceae)
Guava	*Psidium guajava* (Myrtaceae)
Gum, gully	*Eucalyptus smithii* (Myrtaceae)
Gum, rainbow	*Eucalyptus deglupta* (Myrtaceae)
Handkerchief tree	*Davidia involucrata* (Nyssaceae)
Hardy gloxinias	*Incarvillea* spp. (Bignoniaceae)
Hart's-tongue	*Asplenium scolopendrium* (Aspleniaceae)
Heather, bell	*Erica cinerea* (Ericaceae)
Helleborine, dark-red	*Epipactis atrorubens* (Orchidaceae)
Hemp	*Cannabis sativa* (Cannabaceae)
Honeysuckle, winter-flowering	*Lonicera fragrantissima* (Caprifoliaceae)
Holly	*Ilex aquifolium* (Aquifoliaceae)
Hosta	*Hosta* spp. (Asparagaceae)
Hydrangea	*Hydrangea* spp. (Hydrangeaceae)

Ironbark, mugga	*Eucalyptus sideroxylon* (Myrtaceae)
Ivy	*Hedera helix* (Araliaceae)
Jasmine	*Jasminum* spp. (Oleaceae)
Jasmine, winter	*Jasminum nudiflorum* (Oleaceae)
Jet-bead	*Rhodotypos scandens* (Rosaceae)
Kale	*Brassica oleracea* (Brassicaceae)
Kerria	*Kerria* spp. (Rosaceae)
Knotweed, Japanese	*Reynoutria japonica* (Polygonaceae)
Kohl rabi	*Brassica oleracea* (Brassicaceae)
kōwhai ngutu-kākā	*Clianthus puniceus* (Fabaceae)
Lavender	*Lavandula angustifolia (Lamiaceae)*
Leek, Egyptian	*Allium ampeloprasum* (Amaryllidaceae)
Lily	*Lilium* spp. (Liliaceae)
Lobster claw	*Clianthus puniceus* (Fabaceae)
Lychee	*Litchi chinensis* (Sapindaceae)
Madder	*Rubia tinctorum* (Rubiaceae)
Magnolia	*Magnolia* spp. (Magnoliaceae)
Magnolia, southern	*Magnolia grandiflora* (Magnoliaceae)
Maize	*Zea mays* (Poaceae)
Mallow, Chinese	*Malva verticillata* (Malvaceae)
Mandarin	*Citrus reticulata* (Rutaceae)
Mandrake	*Mandragora* (Solanaceae)
Mango	*Mangifera indica* (Anacardiaceae)
Manioc	*Mandioca esculenta* (Euphorbiaceae)
Maple	*Acer* spp. (Sapindaceae)
Meadow-grass, smooth	*Poa pratensis* (Poaceae)
Monkey pot	*Lecythis* (Lecythidaceae)
Monkeyflower, musk	*Erythranthe moschata* (Phrymaceae)
Monkeyflower, scarlet	*Erythranthe cardinalis* (Phrymaceae)
Monkshood	*Aconitum napellus* (Ranunculaceae)
Monkshood, yellow	*Aconitum anthora* (Ranunculaceae)
Mouse-ear, sea	*Cerastium diffusum* (Caryophyllaceae)
Mulberry	*Morus* spp. (Moraceae)
Mushroom, cultivated	*Agaricus* spp. (Agaricaceae)
Myrrh	*Commiphora* spp. (Burseraceae)
Nettle, common	*Urtica dioica* (Urticaceae)
Nutmeg	*Myristica fragrans* (Myristicaceae)
Oak	*Quercus* spp. (Fagaceae)
Oak, cork	*Quercus suber* (Fagaceae)
Olive, European	*Olea europaea* (Oleaceae)
Onion	*Allium cepa* (Amaryllidaceae)
Paeony	*Paeonia* spp. (Paeoniaceae)
Palm, date	*Phoenix dactylifera* (Arecaceae)
Palm, doum	*Hyphaene thebaica* (Arecaceae)
Palm, talipot	*Corypha umbraculifera* (Arecaceae)
Pandan	*Pandanus amaryllifolius* (Pandanaceae)
Papaya	*Carica papaya* (Caricaceae)
Papyrus	*Cyperus papyrus* (Cyperaceae)
Pasque flower	*Anemone pulsatilla* (Ranunculaceae)
Passionflower	*Passiflora* spp. (Passifloraceae)
Passionflower, Brazilian	*Passiflora amethystine* (Passifloraceae)
Pear	*Pyrus* spp. (Rosaceae)
Pelican flower	*Aristolochia gigantea* (Aristolochiaceae)
Pfaffenpint	*Arum maculatum* (Araceae)
Philodendron, comb-leaf	*Philodendron pinnatifidum* (Araceae)
Pied d'veau	*Arum maculatum* (Araceae)
Pine	*Pinus* spp. (Pinaceae)
Pine, Corsican	*Pinus nigra* subsp. *laricio* (Pinaceae)
Pine, Scots	*Pinus sylvestris* (Pinaceae)
Pine, stone	*Pinus pinea* (Pinaceae)
Pineapple	*Ananas comosus* (Bromeliaceae)
Pine-pink orchid	*Bletia purpurea* (Orchidaceae)
Pintle, cuckoo	*Arum maculatum* (Araceae)

Pintle, priest's	*Arum maculatum* (Araceae)
Pitcher plant	*Nepenthes* spp. (Nepenthaceae)
Plantain, greater	*Plantago major* (Plantaginaceae)
Plum	*Prunus domestica* (Rosaceae)
Pomegranate, wild	*Burchellia bubalina* (Rubiaceae)
Poplar	*Populus* spp. (Salicaceae)
Potato	*Solanum tuberosum* (Solanaceae)
Pride of Burma	*Amherstia nobilis* (Fabaceae)
Pride of India	*Koelreuteria paniculata* (Sapindaceae)
Primrose	*Primula vulgaris* (Primulaceae)
Primula	*Primula* spp. (Primulaceae)
Qinghao	*Artemisia annua* (Asteraceae)
Quinine	*Cinchona* spp. (Rubiaceae)
Ragwort, Oxford	*Senecio squalidus* (Asteraceae)
Redwood, giant	*Sequoiadendron giganteum* (Cupressaceae)
Reed mace	*Typha latifolia* (Typhaceae)
Rhododendron	*Rhododendron* spp. (Ericaceae)
Rhubarb	*Rheum* spp. (Polygonaceae)
Rhubarb, Sikkim	*Rheum nobile* (Polygonaceae)
Ribbon fern	*Pteris cretica* (Pteridaceae)
Richweed	*Collinsonia canadensis* (Lamiaceae)
Rose locust	*Robinia hispida* (Fabaceae)
Rubber	*Hevea brasiliensis* (Euphorbiaceae)
Rye	*Secale cereale* (Poaceae)
Ryegrass, perennial	*Lolium perenne* (Poaceae)
Safflower	*Carthamus tinctorius* (Asteraceae)
Saffron	*Crocus sativus* (Iridaceae)
Sawfly orchid	*Ophrys tenthredinifera* (Orchidaceae)
Sensitive plant	*Calliandra houstoniana* var. *anomala* (Fabaceae)
Skinner's cattleya	*Guarianthe skinneri* (Orchidaceae)
Slipper orchid	*Cyperipedium calceolus* (Orchidaceae)
Snapdragon	*Antirrhinum* spp. (Plantaginaceae)
Spiraea	*Spiraea* spp. (Rosaceae)
Spruce	*Picea* spp. (Pinaceae)
Spurge, cypress	*Euphorbia cyparissias* (Euphorbiaceae)
Stewartia, Japanese	*Stewartia pseudocamellia* (Theaceae)
Sugar	*Saccharum* spp. (Poaceae)
Sumac, tanner's	*Rhus coriaria* (Anacardiaceae)
Sunflower	*Helianthus* spp. (Asteraceae)
Sunflower, annual	*Helianthus annuus* (Asteraceae)
Sweet pea	*Lathyrus odoratus* (Fabaceae)
Tea	*Camellia sinensis* (Theaceae)
Thyme, common	*Thymus vulgaris* (Lamiaceae)
Thyme, lemon	*Thymus pulegioides* (Lamiaceae)
Toadflax, yellow	*Linaria vulgaris* (Plantaginaceae)
Tobacco	*Nicotiana tabacum* (Solanaceae)
Tomato	*Solanum lycopersicum* (Solanaceae)
Tree-of-heaven	*Ailanthus altissima* (Simaroubaceae)
Tulip	*Tulipa* spp. (Liliaceae)
Twayblade	*Neottia ovata* (Orchidaceae)
Upas tree	*Antiaris toxicaria* (Euphorbiaceae)
Vanilla	*Vanilla planifolia* (Orchidaceae)
Viburnum	*Viburnum* spp. (Caprifoliaceae)
Wake robin	*Arum maculatum* (Araceae)
Water caltrop	*Trapa natans* var. *natans* (Lythraceae)
Water caltrop, Indian	*Trapa natans* var. *bispinosa* (Lythraceae)
Water lily	*Nymphaea* spp. (Nymphaeaceae)
Water lily, Amazonian	*Victoria amazonica* (Nymphaeaceae)

Water lily, yellow	*Nuphar lutea* (Nymphaeaceae)
Welwitschia	*Welwitschia mirabilis* (Welwitschiaceae)
Whitlow grass, common	*Erophila verna* (Brassicaceae)
Wisteria	*Wisteria* spp. (Fabaceae)
Witch hazel	*Hamamelis* spp. (Hamamelidaceae)
Witch hazel, Virginian	*Hamamelis virginiana* (Hamamelidaceae)
Wolfsbane, northern	*Aconitum lycoctonum* (Ranunculaceae)
Yarrow	*Achillea millefolium* (Asteraceae)
Yew	*Taxus baccata* (Taxaceae)

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